PREPOSITIONED TRAILERS FOR AIRCRAFT BATTLE DAMAGE REPAIR SUPPORT

THESIS

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Abstract

Air superiority is essential in today's wartime environment. Aircraft that are damaged and not returned to combat can have a considerable impact on the quest for dominance in the air. To maintain operational effectiveness, an organization must have the capability to quickly repair damaged aircraft. The purpose of an Aircraft Battle Damage Repair (ABDR) program is to rapidly and effectively repair damaged aircraft to fly additional operational sorties and further contribute to wartime objectives. This capability must consist of providing the necessary tools and equipment for the rapid repair of aircraft.

When an ABDR team deploys in support of an organization in a wartime environment, it is expected that the team will be fully functional, autonomous, and have on hand the resources necessary to complete all tasks. From a logistics standpoint, this is a feasible objective using different methods, with the present method used being prepositioning. During combat operations, Air Mobility Command (AMC) is heavily tasked with movement of personnel and equipment. The prepositioning of ABDR trailers could provide relief on AMC resources already strained to their limits.

This research seeks to determine if the AF should continue to preposition ABDR trailers to augment strategic airlift during combat operations by determining the best course of action for providing ABDR trailers to ABDR teams during combat operations. This research will evaluate the effectiveness of both prepositioning and airlifting ABDR trailers.

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Scott M. Murray

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I. Introduction

Background

In today's wartime environment, air superiority is vital. Aircraft that are damaged and not returned to combat can have a considerable impact on the quest for dominance in the air. Throughout the history of aerial warfare aircraft have sustained significant damage due to enemy action. To maintain operational effectiveness, an organization must have the capability to quickly repair damaged aircraft. The purpose of an Aircraft Battle Damage Repair (ABDR) program is to rapidly and effectively repair damaged aircraft so they can fly additional operational sorties and further contribute to wartime objectives (T.O. 1-1H-39, 2002; vii).

In peacetime, maintenance standards and repairs are based on increasing the operational life of the aircraft. Repairs are designed to restore the original strength to a structure and to last the duration of the aircraft's life. During a wartime environment, the accomplishment of damage repair to peacetime standards would take too long and lead to a decrease in available aircraft. Therefore, a capability must be developed to return damaged aircraft to combat in the shortest possible time. This capability must consist of three aspects with regard to preparations which will have the potential to significantly increase the number of aircraft returned to combat. These are: 1) allowing the use of

time-saving temporary repairs, 2) ensuring maintenance personnel are trained in new skills and techniques, and 3) providing the necessary tools and equipment for the rapid repair of aircraft (T.O. 1-1H-39, 2002; vii). The third aspect, tools and equipment, provides the focus for this research project. An effective ABDR program must have the right resources in the right place at the right time.

The United States Air Force (USAF) has developed trailers containing ABDR tools and equipment necessary for the repair of damaged aircraft. The trailers are designed to support basic repair needs of a maintenance team working on an aircraft. Currently, the trailers are prepositioned throughout the world, ready for use as wartime requirements may dictate.

Definition of Key Terms

To assist in understanding some of the terminology used for this research, definitions of key terms are provided.

<u>Aircraft Battle Damage</u>- damage and/or malfunction, typically caused by munitions or their effects whether self-inflicted or resulting from enemy or friendly fire or by ground mishap, encountered during combat operations (T.O. 1-1H-39, 2002; vii).

<u>Airlift</u>- the transportation of personnel and material through the air, which can be applied across the entire range of military operations to achieve or support objectives and can achieve tactical through strategic effects (AFDD 1, 2003:61).

<u>Airlift Capability</u>- the total capacity expressed in terms of passengers and/or weight/cubic displacement of cargo that can be carried at any one time to a given destination by available airlift (JP 1-02, 2003).

Depot Maintenance- maintenance performed on materiel requiring major overhaul or a complete rebuild of parts, assemblies, subassemblies, and end-items, including the manufacture of parts, modifications, testing, and reclamation as required. Depot maintenance serves to support lower categories of maintenance by providing technical assistance and performing that maintenance beyond their responsibility (JP 1-02, 2003).

Intermediate Maintenance- maintenance that is the responsibility of and performed by designated maintenance activities for direct support of using organizations. Its phases normally consist of repair or replacement of damages or unserviceable parts, the emergency manufacture of nonavailable parts, and providing technical assistance to using organizations (JP 1-02, 2003).

Intertheater Airlift- the common-user airlift linking theaters to the Continental United States (CONUS) and to other theaters as well as the airlift within CONUS. The majority of these air mobility assets is assigned to the Commander, United States Transportation Command (USTRANSCOM). Because of the intertheater ranges usually involved, intertheater airlift is normally conducted by the heavy, longer range, intercontinental airlift assets but may be augmented with shorter range aircraft when required (JP 1-02, 2003).

Intratheater Airlift- Airlift conducted within a theater. Assets assigned to a geographic combatant commander or attached to a subordinate joint force commander normally conduct intratheater airlift operations. Intratheater airlift provides air movement and delivery of personnel and equipment directly into objective areas through airlanding, airdrop, extraction, or other delivery techniques as well as the air logistic support of all theater forces, including those engaged in combat operations, to meet

specific theater objectives and requirements. During large-scale operations, US Transportation Command assets may be tasked to augment intratheater airlift operations, and may be temporarily attached to a joint force commander (JP 1-02, 2003).

Logistics- the science of planning and carrying out the maintenance and movement of forces (JP 1-02, 2003).

Prepositioning- placing military units, equipment, or supplies at or near the point of planned use or at a designated location to reduce reaction time, and to ensure timely support of a specific force during initial phases of an operation (JP 1-02, 2003).

Time-Phased Force and Deployment Data (TPFDD)- the Joint Operation Planning and Execution System database portion of an operation plan; it contains time-phased force data, non-unit-related cargo and personnel data, and movement data for the operation plan, including the following: a. In-place units; b. Units to be deployed to support the operation plan with a priority indicating the desired sequence for their arrival at the port of debarkation; c. Routing of forces to be deployed; d. Movement data associated with deploying forces; e. Estimates of non-unit-related cargo and personnel movements to be conducted concurrently with the deployment of forces; and f. Estimate of transportation requirements that must be fulfilled by common-user lift resources as well as those requirements that can be fulfilled by assigned or attached transportation resources (JP 1-02, 2003).

Unit Type Code (UTC)- a Joint Chiefs of Staff developed and assigned code, consisting of five characters that uniquely identify a “typeunit” (JP 1-02, 2003).

War Reserve Materiel (WRM) - stocks of materiel amassed in peacetime to meet the increase in military requirements consequent upon an outbreak of war (JP 1-02, 2003).

Problem

Historically, the capability to rapidly repair combat damage has been vital to the ability to maintain wartime aircraft availability and sortie rates, especially when considering the likelihood of intense battlefield conditions and demands. USAF resources, in terms of people and airframes, will be constrained to what is available at the onset of hostilities. Thus, it is necessary to have the capability to maximize the combat sortie potential of all possessed aircraft. The concept is to use temporary but sound repairs to make the aircraft safe for flight and to return at least one of its designed mission capabilities. The immediate goal is to enable the aircraft to fly at least one more sortie and contribute to the war effort at the same time.

However, since the Vietnam War, the United States has been involved in either low-intensity conflicts or conflicts where we have quickly gained air superiority. Most battle damage incurred has come from Close Air Support missions and self-inflicted damage (accidents). These types of conflicts, due to relatively small aircraft damage rates, have historically led to fewer needs for forward-deployed operations, thus a presumed decreased need for an ABDR function. Some Air Force leaders currently believe that prepositioned ABDR trailers may no longer prove to be a critical function given today's warfare environment. The mindset is, bombing occurs from high altitudes and no one sees the enemy, or, we run over the enemy with massive air power and the war is over before we need additional sorties. However, this mentality could lead to a

false sense of security, resulting in the AF not being prepared when faced with a major conflict where air superiority is not so easily gained. This lack of preparation could quite possibly surface in the limitations of airlift capability. During combat operations, Air Mobility Command (AMC) is heavily tasked with movement of personnel and equipment. The prepositioning of ABDR trailers could provide relief on AMC resources already strained to their limits.

Research Objective

The great possibility of aircraft battle damage occurring in a wartime environment makes it imperative that ABDR trailers are available when needed. The primary objective of this research effort is to determine the best course of action for providing ABDR trailers to ABDR teams during combat operations. This research will evaluate the effectiveness of both prepositioning and airlifting ABDR trailers. This study may serve to quantify some decisions concerning the use and placement of ABDR trailers. Further, the results of this study may influence future decisions concerning ABDR trailer locations. This study should be useful to personnel in ABDR units who are involved in making decisions concerning ABDR trailers and provide current planners with a clearer framework to guide their decision-making process.

Research Question

When an ABDR team deploys in support of an organization in a wartime environment, it is expected that the team will be fully functional, autonomous, and have on hand the resources necessary to complete any and all tasks. From a logistics standpoint, this is a feasible objective through the use of different methods, with the present method being prepositioning. Current changes in AF operations have led to the

primary research question, “Should the AF continue to use the prepositioned ABDR trailer process to augment strategic airlift during combat operations?”

Investigative Questions

The following investigative questions look for answers to meet the objective of this research effort:

- How has ABDR historically provided mission support?
- How does the ABDR function provide mission support in today’s operational environment?
- How does the current method of prepositioning ABDR trailers in strategic locations throughout the world meet time requirements in potential wartime situations?
- What support does airlift, assuming trailers are not prepositioned, provide for ABDR capability in a wartime environment?

Scope and Limitations

Previous studies have shown that the proper application of ABDR capabilities can have a positive impact on sortie rates (T.O. 1-1H-39, 2002; vii). This research assumes that there is a difference in how those rates are impacted based on whether ABDR trailers are prepositioned in preparation for combat or airlifted at the actual time of combat. The scope of this research may be limited in three ways. First, the case study methodology is the chosen method for conducting this research. The use of the case study methodology limits specific findings to the cases under study. However, this fact does not preclude these findings from being generalized beyond the cases examined in this research. The aim is to provide ideas of how to best provide ABDR trailers to an ABDR team during

combat operations based on the case findings and theory. Second, much of the data relevant to this research will be gathered from numerous experts within the field of ABDR. Some conclusions may be based on their subjective responses. Finally, this research only deals with the C-17 aircraft for airlift purposes, and only one location for a potential area of conflict. Even though this research is limited to this aircraft along with only one location, it can be easily translated to airlift capability in general.

Summary

This chapter has introduced the focus of the study, determining the best method for providing ABDR trailers in support of ABDR teams. In addition, it has provided a general background of ABDR and the proposed problem. Further, the research objective, the research question, and the investigative questions were introduced. Finally, the chapter concluded with the scope and limitations of this research. In chapter two, an in-depth review of available literature on ABDR, prepositioning, and airlift will be presented.

II. Literature Review

Overview

The purpose of this chapter is to examine literature related to the areas of ABDR, prepositioning, and airlift. This chapter is broken into three major sections. The first section describes past experiences in the field of ABDR and the evolution process utilized to reach current ABDR practices. The second section explores the concept of prepositioning, including its history and overall effectiveness. The final section concludes the chapter with a review of airlift capability and current shortfalls.

ABDR

Early Historical Experience

ABDR has a long history, beginning in World War I and continually refined, to include the most recent conflict, Operation Iraqi Freedom. The first signs of ABDR use date back to when aerial combat was first encountered. In World War I, the Army did not see aviation as an important part of the war effort. The aircraft that were available were in poor condition due to heavy use and spare parts were lacking. The first recorded cases of damage repair occurred at this time when airmen used discarded French farm machinery to repair aircraft (Voyls, 1983:1). Though the use of air power was still in its infancy, it was quickly recognized that in order for air power to contribute to the overall war effort there was a need to repair aircraft rapidly by almost any means possible.

Early in World War II the allied air forces were at a numerical disadvantage and realized that each and every aircraft was a valuable asset. The United States and its allies

were not able to establish air superiority at the beginning of the war due to the technical and numerical superiority of the German and Japanese forces (Holcomb, 1994:10). The true concept of ABDR was born as every effort was made to quickly repair the damaged aircraft and return them to flying status. Maintainers learned different repair techniques that drastically reduced aircraft repair times. In response to a slow supply line, some maintainers found they also had to fabricate suitable substitution parts and develop their own took kits. In many cases, weeks were saved in the overall repair process (ABDREH, 1996:2). By the end of World War II, due in large part to rapid aircraft repair, the United States was able to amass over 50,000 aircraft (Schlight, 1988:2).

The Korean War saw the introduction of the jet age and the jet aircraft proved to be more reliable than propeller drive aircraft as the United States gained air superiority. In contrast to World War II, the United States aircraft were technically and numerically superior when compared to enemy aircraft. Damage to aircraft was for the most part limited and spare parts and materials were readily available for aircraft that were damaged (Holcomb, 1994:10). With the achievement of air superiority, the need to repair damaged aircraft expediently was not a major issue.

USAF Experience in the Vietnam War

The Vietnam War saw a drastic change to the Korean War philosophy concerning ABDR. Initially, the United States acted only as military advisors but eventually the United States became fully engaged combatant participants (Schlight, 1988:2). During this war, 11,836 incidents of damage to fixed-wing aircraft were recorded (Vice, Lindenmuth, and Foulk, 1986:2). Early on it was evident that there were problems with the repair and maintenance of damaged aircraft. In September of 1963, 23 aircraft

operating out of Bien Hoa airfield had been inflicted with battle damage. Because the USAF lacked suitable facilities and personnel to repair damaged aircraft, it was forced to hire Air Asia to accomplish depot-level maintenance (Futrell, 1981:181). Additionally, three American contractors, Dynalectron, Lear Seigler, and Lockheed, were hired to fix damaged aircraft (Diamond and Luthor, 1991:xv). According to the Air Force Systems Command, 56 percent of the total aircraft in theater sustained aircraft combat damage. Pacific Air Forces data collected during the war showed that for every F-4 (the predominant fighter aircraft) lost, four returned with combat battle damage and in a 12-month period (April 1972-March 1973) 135 F-4 aircraft returned with battle damage (Foster, 1989:7). The number of aircraft that sustained some type of damage began to grow the longer the United States stayed involved.

The increasing number of damaged aircraft was cause for concern for military leaders and the decision was made to increase damaged aircraft supportability through additional depot-level support. Most of the damaged aircraft were returning to their base of origin and maintenance personnel were not able to keep pace with the high repair tempo (ABDREH, 1996:3). The AF was ill equipped and not organized to sustain a rapid repair mission, resulting in an adverse effect to operational readiness. To combat this, in 1965 the Air Force Logistics Command (AFLC) authorized the formation of Rapid Area Maintenance (RAM) teams (Diamond and Luthor, 1991:xv).

RAM teams were developed to provide depot-level support to the operational forces engaged in combat. The premise used for the generation of a RAM team was if an aircraft repair was estimated to require more than five days for repair, then the operational unit was required to request assistance from AFLC (McMahon, 1986:12).

The RAM teams consisted of highly trained personnel, mostly civilian, from all five of the current Air Logistic Centers (ALC) in existence. During the Vietnam War, more than 1000 aircraft were repaired by RAM teams mobilized by AFLC (Diamond and Luthor, 1991:xvi). Contributing to the success of the RAM teams was that the personnel were expertly trained in accelerated repairs and AFLC was able to maximize the supply line to support the increase in requests for parts and supplies. ABDR tool kits were becoming more uniform, resulting in consistent repairs. However, some major concerns with the RAM teams began to surface--the increasing cost of sending a large number of civilians to supplement the war effort (ABDREH, 1996:3) and that the deployment of the RAM teams, due to constraining civilian issues, was not responsive enough in a combat environment (Moseley, 1988:5). These concerns led to the development of the Combat Logistics Support Squadron (CLSS).

In 1967, AFLC created five new CLSSs and assigned one each to the five ALCs. The CLSS was designed to provide support in the areas of maintenance, transportation, and supply. The primary repair activities for ABDR were shifted to operational maintenance and augmentation was supplied by the CLSSs. All of the military personnel previously assigned to a RAM team were now assigned to a CLSS. Operational units utilized their individual tool kits coupled with special tooling used by the former RAM teams and controlled by the ALCs (Huff, 2003). The CLSSs were deployed throughout the theater for the remainder of the war. However, the civilians were not disregarded. Due to a lack of trained military personnel, many civilians continued to support CLSS maintenance actions during the war effort (ABDREH, 1996:4).

Israeli Experience in the Yom Kipper War

The USAF was not the only military utilizing ABDR. The Israeli Air Force (IAF) utilized ABDR concepts during the Yom Kipper War. The war, involving Israel, Syria, and Egypt, started in October of 1973 and caught the country of Israel by surprise (ABDREH, 1996:4). This war was considered a high-intensity conflict and required a different approach to ABDR when compared to the United States' approach in the Vietnam War. Within 18 days of the start of the war, the IAF lost over 30 percent of its aircraft; 80 percent of these losses occurred in the first 5 days (Maxwell, 1986:45). The goal of the Israeli ABDR program was to repair as many aircraft as possible at the field level due to time constraints and the limited resources available. Maintenance personnel, along with ABDR specific tools and equipment, were placed in the field and integrated into the operational maintenance units while the United States maintained a separate maintenance function in the Vietnam War. These same personnel were also authorized to perform depot-level repairs (McMahon, 1986:15). The IAF saw this as an important part of the overall ABDR process in order to return damaged aircraft to operational status expeditiously.

The IAF was also able to perform many permanent fixes on damaged aircraft even though the objective was rapid repair. Permanent fixes were made possible due to the presence of engineers in the field at all times, availability of proper tool kits, and the relatively short supply line (McMahon, 1986:15). The IAF knew the importance of having engineers in the field and ensured their engineers had extensive knowledge of the aircraft structures and ABDR processes (Harris, 1978:25). The IAF also identified four key lessons based on experiences during the war. First, ABDR teams needed to be in

place and ready at the start of a conflict. Second, damage assessment needed to be accurate. ABDR assessors must have a solid knowledge of damage identification. Third, each and every battle damage repair was distinctive, requiring team members to use creativity based on ABDR experience. Finally, as skilled as the ABDR team members were, many repairs could not have been accomplished without major module replacement spares (Feiler, 1989:17). These concepts would prove to be valuable lessons to the British as they became involved in the Falklands War.

British Experience in the Falklands War

In 1976, based largely on lessons learned through studying IAF actions during the Yom Kipper War, the British developed their own official ABDR program. This was not the first experience the British had with ABDR concepts. During World War II, aircraft battle damage was a common occurrence and the British developed repair techniques and repair facilities to handle aircraft damage. Despite this, after the war the British deemed a wartime repair organization as unnecessary and aircraft maintenance personnel and facilities were organized based on peacetime objectives (Harris, 1978:25). However, after the Yom Kipper War, the British recognized that a more mature ABDR program, based on wartime objectives, was essential.

After development of their ABDR program, the British were not able to validate the program until the Falklands War in 1982. During this war, the primary aircraft used was the Royal Air Force (RAF) GR Mk-1 Harrier. In fact, every RAF Harrier committed to the conflict had to be repaired in some form at least once (Peecook, 1991:48). The British ABDR program proved to be successful because it was very similar to the Israeli ABDR program. Based on their success, the British identified fourteen principles

relevant to future success of an ABDR program (McMahon, 1986:19). These principles are as follows:

1. Assessment is very important—the assessor is the key man.
2. Future aircraft should be designed for survivability.
3. Manuals are for guidance only.
4. Initiative and ingenuity count for a lot.
5. Documentation is still important.
6. Go/no go lists are important.
7. Additional spares are necessary to support ABDR.
8. Access holes need to be cut for assessment and/or repair.
9. Robbing from damaged aircraft is very much a part of ABDR.
10. Kits are essential.
11. Transparency repair methods are lacking.
12. Repairs should be the best possible in the time available.
13. Self-sealing fuel tanks are needed.
14. The pilot is not always aware that damage has occurred.

It is important to note the tenth principle, “Kits are essential.” The RAF realized the criticality of tool accessibility for its ABDR teams and its importance in the development of an effective ABDR program.

During Operation Desert Storm, the RAF again displayed the capabilities of its ABDR function. A total of seven ABDR teams were deployed to different bases within the theater of operations. All of the teams were in place at the start of the conflict and were successful in performing damage repairs on Jaguar, Tornado, and C-130 aircraft.

USAF Experience in Persian Gulf War

On August 2 1990 the country of Kuwait was invaded by the country of Iraq. Almost immediately, the United States began a five and a half month build up of personnel and equipment, an enormous operation titled Desert Shield. On 17 January 1991, the United States initiated Operation Desert Storm and 45 days later achieved victory with the surrender of Iraq (Hutchison, 1995:1). Air superiority was a major contributor to the success of Operation Desert Storm. President Bush would later say, "General McPeak, like the rest of the Air Force, was right on target… lesson number one from the Gulf War is the value of airpower" (Coyne, 1992:1).

A total of forty-two ABDR teams deployed in support of Operation Desert Storm to provide rapid repair capability to the flying units (Coyne, 1992:133). Many different type of aircraft were damaged and repaired, with the bulk of the damaged aircraft coming from A-10 missions. The A-10 aircraft was used for close support of ground forces and low level attacks on enemy tanks. The severity of some of the damage necessitated repairs that would normally need to be accomplished at depot-level repair facilities. One A-10 returned with 380 bullet holes, two others returned with most of their tail section missing, and another one returned with a large part of the right wing missing. Each of these aircraft was quickly repaired and flew combat missions again (Coyne, 1992:134). ABDR teams in the Gulf War provided support to many different types of aircraft, including A-10s, F-15s, F-16s, B-52s, and C-130s. This support was facilitated by the fact that the ABDR teams possessed the proper tools and equipment. One ABDR team even provided support to the Army by repairing a UH-60 helicopter (Coyne, 1992:134).

Throughout the history of warfare, ABDR teams, whether from the United States, Israel, or Great Britain, displayed unique capabilities. These capabilities included the ability to perform timesaving temporary repairs, to properly train personnel in new skills and techniques required to effect rapid repairs, and to assure that the ABDR tool kits contained the necessary equipment and materials required to accomplish ABDR effectively and rapidly. It is important to understand these concepts in order to fully comprehend the current ABDR program and its development.

Program Development

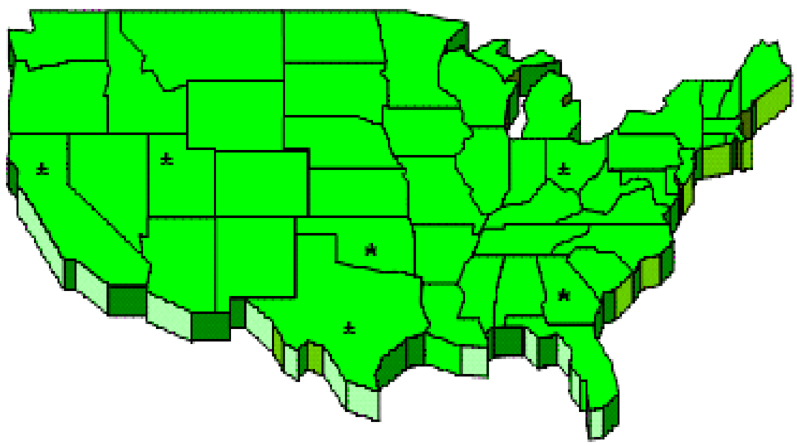
By the end of the Vietnam War, the USAF inventory of aircraft decreased from 50,000 to 15,000. AF leaders were concerned over the impact battle damaged aircraft would have on a future conflict due to the already shrinking aircraft inventory. War experiences, both the United States and other countries, had already shown the benefits that could be provided by ABDR teams. Although the USAF developed RAM teams and CLSSs during the Vietnam War, there was still not a formal ABDR program in place (Holcomb, 1994:12). The decision to begin an ABDR program was prompted in response to the 1976 HQ USAF Surge Sortie Rate Conference Report recommendation. The recommendation was that AFLC develop new manpower deployment policies which would enable them to send the necessary elements of maintenance personnel to employment bases as soon as possible after the warning of war. The need for an ABDR program was emphasized by the results of an analysis of an A-10 aircraft operation (to be discussed), the Southeast Asia Conflict, and the Israeli combat damage experience (Huff, 2003).

In 1981, a central office was created by AFLC at the Sacramento ALC to initiate the establishment of a formal AF ABDR program. Currently, the ABDR Program Office (PO) is located at Wright Patterson Air Force Base (AFB), Ohio. The ABDR PO provides overall management of tasks associated with development, implementation, maintenance, and support required to enhance ABDR capability and is responsible for oversight of all CLSS operations, to include ABDR trailers (AFMCI 10-2002, 2001:7).

CLSS

AF combat forces require maximum availability of weapons systems to successfully accomplish their wartime mission. A CLSS contributes to maintaining an effective combat capability through battle damage and depot level support, and supply and transportation support. The current wartime mission of a CLSS is to "provide the unified Commander-in-Chiefs and Air Force commanders with dedicated, flexible, and mission-ready military ABDR, depot level maintenance support, limited Jet Engine Intermediate Maintenance augmentation, Rapid Area Distribution Support (RADS), and Command and Control (C2) teams that provide specialized logistics capabilities to directly support AF operations" (AFMCI 10-202, 2001:8). CLSSs have evolved and become an integral part of the overall USAF ABDR program. They provide worldwide teams which deploy to perform all aspects of ABDR and also assist the organization where possible with scheduled and unscheduled standard or heavy maintenance. When these teams are not deployed, they assist the ALC directorates in performing depot-level maintenance and aircraft modifications at various depots (Kitchens, 1997:5). The use of CLSS personnel in depot work centers provides valuable working experience, which contributes to their increased expertise in aircraft maintenance, engine repair, supply, and

transportation functions. To facilitate the accomplishment of these functions, CLSSs are located at various locations in the United States. Figure 1 shows the current locations of the CLSSs.



Location	Active	Reserve
Hill AFB, Utah	649 CLSS	419 CLSS
Lackland AFB, Texas		433 CLSS
Robins AFB, Georgia	653 CLSS	622 CLSS
Tinker AFB, Oklahoma	654 CLSS	507 CLSS
Beale AFB, California		940 CLSS
Wright Patterson AFB, Ohio		445 CLSS

Figure 1. CLSS Locations

(Johnson, 2003)

CLSS teams train to meet the dynamic mission requirements regardless of the environment. CLSS units, as eluded to earlier, consist of military personnel in selected maintenance, supply, transportation, and logistician specialties. A description of areas of expertise is as follows:

Maintenance- provides battle damage repair capability for the AF. ABDR teams are trained to provide all necessary assessment and repair. The teams contain a specific

number and range of skills to provide ABDR for specific aircraft. The limited Jet Engine Intermediate Maintenance function supports F100, F110, and F101 engines (Johnson, 2003).

Supply- supply teams are deployed to augment the establishment of forward operating locations and existing supply operations. They can deploy/redeploy to perform such actions as recovery, closure, and drawdown (Johnson, 2003).

Transportation- transportation teams augment existing freight packaging operations. Teams can be redeployed to other in-theater locations for recovery or other RADS requirements, such as site activation or closure, drawdown, and special packaging tasks (Johnson, 2003).

C2- C2 teams augment warfighting crisis action teams to orchestrate deployment of in-theater CLSS forces for AF commanders. These teams provide data on capability and availability of CLSS forces during wartime or contingency operations (Johnson, 2003).

In 1992, operational units were still tasked with ABDR responsibilities and CLSSs with augmentation. The operational units stored ABDR tools in boxes shaped like footlockers and transported the kits in any manner available during the mobilization process. Several problems developed rather quickly under this process. The operational units were already burdened with daily maintenance and the line between typical everyday repair activities and ABDR repairs became blurred. Maintenance inspections revealed incorrect repair procedures due to lack of proper ABDR training, over worked maintainers, and a lack of both quality and quantity of tools and materials to complete all maintenance actions.

CLSSs were being trained at a very high level in depot repairs, leading to a very productive maintenance force AF-wide. However, the down side of maintenance rested with the operational units. Annual ABDR training requirements stressed the already undermanned aircraft maintenance force. Redundant tool kits were in every unit in the AF and cost in both man-hours and material was excessive (Huff, 2003). Inspector General activities led to the recommendation to move ABDR functions to the CLSSs for several reasons. First, the engineering support for the CLSSs was already in place at the ALCs. Second, highly qualified maintainers were already trained and ready for the ABDR task. Finally, tool systems would not have to be procured and maintained in every operational unit. On 30 May 95, the AF changed the ABDR policy by eliminating the requirement for operational units to have an ABDR program and gave the primary responsibility to Air Force Materiel Command (AFMC) and the CLSSs (Johnson, 2003).

Every CLSS was assigned defined UTC positions that were married to the specific aircraft that they were trained on for depot maintenance activities, thus reducing the training time for ABDR repairs. ABDR trailers were developed based on number of available personnel for each UTC and number of specific aircraft under their area of responsibility. Trailers were then built, deployed, and prepositioned at locations conducive for a quick response as war requirements dictate (Huff, 2003).

Trailers

To meet the requirement to establish an ABDR capability, the AF implemented a unique organization. As previously stated, CLSSs provide highly trained worldwide deployable military teams to accomplish ABDR. The CLSSs deploy with a limited amount of specialized tools and equipment to support a specific number of primary

authorized aircraft. They depend on support from available facilities at deployed locations as well as routine and specialized support equipment. Although some potential conflicts may be predictable as tensions build over time, there is still a high possibility of a conflict with little to no warning. Thus, the AF is often unable to anticipate the need for ABDR and a quick response time is required. In order to meet this response time, ABDR trailers are transported from prepositioned locations to deployed locations to support CLSS ABDR team operations.

Locations. There are a total of 96 ABDR trailers, to include 93 generic, 2 F-117 specific, and 1 B-2 specific trailers. These trailers are currently prepositioned in locations throughout the world. According to Mr. Bert Nyberg at the ABDR PO (2003), the locations are as follows:

- Thirty-six generic trailers in WRM at Sanem, Luxembourg in support of Central Command (CENTCOM) and European Command (EUCOM) contingencies.

- Thirty-seven generic trailers in WRM at various locations in support of Pacific Command (PACOM) contingencies. These locations include Korea, Japan, Guam, and Diego Garcia.

- Two generic and two F-117 specific trailers in WRM at Ogden ALC in support of a no-plan tasking or contingency involving use of F-117 aircraft.

- Two generic trailers in WRM at Warner-Robins ALC in support of a no-plan tasking.

- Three generic and one B-2 specific trailers in WRM at Oklahoma City ALC in support of a no-plan tasking or contingency involving use of B-2 aircraft.

- Thirteen generic trailers at the various CLSSs in support of training requirements.

Specifications. The ABDR trailers currently in use by the AF were developed with mobility in mind. Trailers were built using MHU-12/M and MHU-141 munitions trailers as platforms for the placement of tool kits (Nyberg, 2003). The munitions trailers were procured through the Defense Reutilization and Marketing Office. When the munitions trailers were matched with the ABDR tool kits and the reconfiguration to an ABDR trailer was accomplished, the National Stock Number was re-identified to exhibit an ABDR trailer. The dimensions of the trailer are L122” x W84” x H88” with full enclosure. The weight is approximately 5,000 pounds fully stocked plus a 1,300 pound composite kit, which equals a total of 6,300 pounds (Nyberg, 2003). Figure 2 and Figure 3 show an ABDR trailer with and without the full enclosure.

Figure 2. ABDR trailer with enclosure

Figure 3. ABDR trailer without enclosure

The trailers are designed to support ABDR teams during the initial stages of a contingency with the host unit providing sustainment and long-term support. The trailers will support teams through the full spectrum of requirements in all environments, from small-scale contingencies to major theater war (Nyberg, 2003).

Effectiveness

Analysis of previous combat experiences has shown that the application of ABDR techniques in a combat operation can be a force multiplier. The ability to quickly return damaged aircraft to the fight can be a critical factor in deciding the outcome of a military conflict. Historically, the importance of repairing damaged aircraft has been dramatic in both long and short conflicts. A study done by the Logistics Management Institute (LMI) on the historical relationship for tactical aircraft shows that for every aircraft lost in combat, three to five are damaged to the point of requiring some type of repair. Combat simulations of future conflicts by LMI show this number could go as high as twenty to one (Srull, Simms, and Schaible, 1989:1). The study also modeled ABDR capability

based on a scenario of a 72-aircraft wing. Battle damage repair levels were broken down into three areas; excellent repair capability, moderate repair capability, and no repair capability. The analysis of the model showed that at the end of ten days, the excellent repair capability (returning 50 percent of the damaged aircraft to combat in 24 hours and 80 percent in 48 hours) produced four times as many aircraft as the no repair capability (Srull et al., 1989:4). Figure 4 illustrates how ABDR capabilities can increase aircraft availability for sortie generation in a wartime scenario.

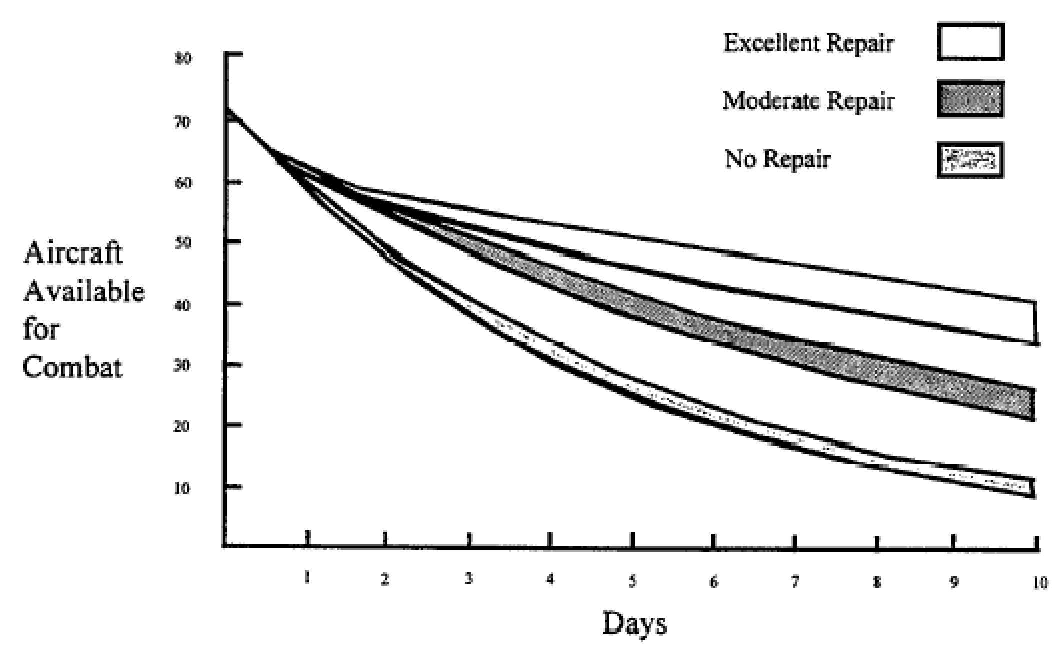


Figure 4. Attrition Rates with Varying Repair Capability

(Srull et al., 1989:4)

A study by the Weapon System Evaluation Group at Arlington, Virginia, made sortie and attrition comparisons for two A-10 squadrons of 48 aircraft. Based on experiences and the current threat, the study assumed a cumulative aircraft destroyed rate of three percent and an associated damage rate of 13 percent. Without an ABDR

capability, the unit could lose up to 23 percent of a total of 777 scheduled sorties, a number equal to 177 sorties in a ten-day period (Johnson, 1976:12). Conversely, if an ABDR capability was available and half of the damaged aircraft could be repaired in six hours and the other half in 18 hours, then 104 sorties could be gained, or 59 percent of the sorties lost without an ABDR capability could be saved (Johnson, 1976:14). Table 1 shows the effect of combat damage on sortie generation. P_A is defined as the probability per sortie that the aircraft will be killed or returned to base with damage too extensive to be repaired in the field. P_D is defined as the probability per sortie of returning to base with damage which can be repaired at a forward operating base (Johnson, 1976:20).

Table 1. Effect of Combat Damage on Sortie Rate

	No Specific Preparations Made for Combat Damage Repair	Preparations Made Specifically for Combat Damage Repair	No Combat Damage Incurred (P_D = 0)
P_A = .02 P_D = .09	727	781	831
P_A = .03 P_D = .13	600	704	777
P_A = .05 P_D = .22	429	536	624

(Johnson, 1978:20)

An excellent example of the importance of an effective ABDR capability is the comparison of the USAF experience during the Vietnam War with the IAF experience during the Yom Kipper War. In the Vietnam War, the USAF was able to repair 46 percent of the damaged F-4 aircraft within 24 hours. Furthermore, repair was accomplished on another 13 percent within 48 hours (Greene, 1980:3). In contrast, the

IAF had a mature ABDR program in place and was able to repair 72 percent of its aircraft within 24 hours (Peecook, 1991:48). The ability to rapidly repair damaged aircraft was critical to the IAF overall war effort. Had the IAF not had the capability to quickly return damaged aircraft to combat, it would have been out of business by the eighth day of the war (Srull et al., 1989:2). The IAF demonstrated that a well-organized ABDR capability could make the difference between winning and losing a war.

During Operation Desert Storm, the USAF operated aircraft from a number of ground bases located in Saudi Arabia, Turkey, Europe, and the United States. Aircraft missions flown ranged from close air support to air interdiction. During these missions, direct enemy action resulted in 39 aircraft receiving damage, with 13 of these aircraft being totally destroyed. Of the remaining 26 damaged aircraft, 25 were repaired and returned to combat (O'Connell, 1996, 1). One of the most notable demonstrations of ABDR capability was when an A-10 aircraft returned with a large part of its right wing missing due to a missile attack. An ABDR crew was able to repair the A-10 using parts from a scrapped A-10 in Sacramento, returning the aircraft to combat in only four days (Henderson, 1991:42). Figure 5 shows the ABDR rates for Operation Desert Storm.

The British RAF also deployed ABDR teams during Operation Desert Storm. These seven teams successfully performed repairs on several aircraft, to include the Jaguar, Tornado, and C-130 aircraft. The ABDR capability displayed by the RAF significantly increased combat power of the British forces during the Gulf War (Holcomb, 1994:28).

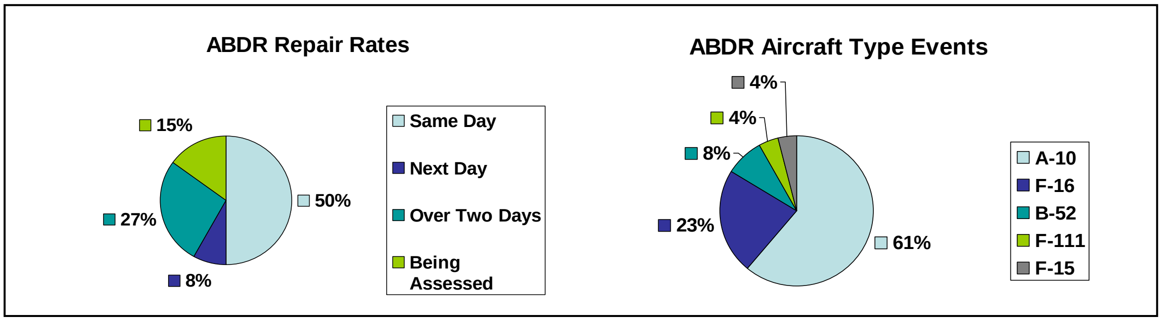


Figure 5. ABDR Rates for Operation Desert Storm

(ABDREH, 1996:1-4)

Although aircraft and enemy defense system characteristics today vary from the studies presented, the damage and attrition rates clearly show the overwhelming effect damaged aircraft can have on an organization's overall ability to launch sorties. An ABDR program that is actively organized and properly trained is essential to sustained operations (Cavitt, 1988:8).

Prepositioning

"*There is nothing more common than to find considerations of supply affecting the strategic lines of a campaign and a war*."
- Carl von Clausewitz

Background

The ability to quickly put together a force and to strike directly at the enemy's strategic and operational centers of gravity is a key premise to air and space power (AFDD 1, 2003:28). According to the AF Chief of Staff, "operational aerospace forces must respond to global taskings within hours" (AFDD 2-4, 1999:i). Prepositioning war material in possible areas of conflict throughout the world is an effective method of maintaining a military posture capable of meeting and deterring various threats of

aggression to the United States. Since these threats are difficult to predict, it has been necessary to preposition for any eventuality on a very large scale throughout the world.

As stated in chapter one, prepositioning is defined as the placing of "military units, equipment, or supplies at or near the point of planned use or at a designated location to reduce reaction time, and to ensure timely support of a specific force during initial phases of an operation" (JP 1-02, 2001). The concept of prepositioning involves storing material in various locations around the world and insuring the availability of the material when war requirements dictate a rapid response. With prepositioning, airlift requirements for personnel delivery become the higher objective and the role of cargo delivery is diminished (Goldstein and Wilcox, 1966:2).

Since the end of World War II, military strategy has been committed to the containment of acts of aggression. Early on this was accomplished through the continuous presence of combat forces and equipment throughout the world. Although forward basing was the dominant principle to insure timely response to any threat or aggression, the prohibitive costs of increased requirements for manpower, equipment, and facilities have offset its advantages. Consequently, prepositioning of WRM equipment such as ABDR trailers has played a significant role in the national defense strategy since its beginnings in the early 1960s (Christie, 1992:9).

During the early post World War II period, it became apparent that the Soviet Union meant to pursue a policy aimed at the establishment of world supremacy. The United States came to the realization that it must develop a capability for rapid response to intervene forcibly to meet acts of aggression. Inherent in such a rapid response is a deployment capability of moving personnel, equipment, and supplies to possible areas of

conflict (Goldstein and Wilcox, 1966:2). But the fact remained that after World War II the military forces of the United States had been considerably reduced. The problem soon discovered was that the United States did not possess the aircraft necessary to meet a possible threat (Estes, 1966:7). From this position of strategic deficiency, the concept of prepositioning evolved.

Evolution of the Concept

Prepositioning came into being in 1962 partially as a result of lessons learned from the Berlin Crisis of 1961 (Franklin, 1985:11). The United States was involved in a post-war confrontation with the Soviet Union over access to West Berlin and it became obvious that reinforcement of Europe could not be accomplished in the time necessary to control the early stages of a conflict if equipment had to be transported. Increasing forward deployed forces was neither economically or politically feasible. Prepositioning was introduced as an alternative by leaving deployed material and equipment in place (Franklin, 1985:12).

The program was first known as a 2-plus-10 program, providing equipment for two divisions and ten support units, and quickly became known as Prepositioned Materials Configured in Unit Sets (POMCUS) (McGlasson, 1981:31). In the late 1960s, a requirement to limit the flow of United States currency to foreign countries resulted in a widespread withdrawal of military forces from overseas locations. President Johnson reduced the level of European forces by one division, one regiment, and other non-divisional forces. While these units withdrew from Europe, the assigned equipment was left behind and increased the number of POMCUS (McGlasson, 1981:32). The development of the POMCUS program combined extensive host nation support

agreements with massive planning for European countries to provide facilities. This assured access to prestocked divisional sets and enhanced the United States capability to airlift forces with equipment and high value, low bulk items not conducive to prepositioning (Franklin, 1985:13).

The evolution of prepositioning continued in the late 1970s and early 1980s. Prepositioning extended outside of the European theater to the Southwest Asia (SWA) theater and led to the introduction of the Rapid Deployment Joint Task Force (RDJTF). The RDJTF, the predecessor to today's United States Central Command, was composed of personnel from each branch of the military. It was developed to in response to rising tensions in the Persian Gulf region and was initially supported by seven prepositioned ships that were stocked with Marine Corps equipment (Lawrence, 1984:24). Efforts to establish land-based prepositioning locations met resistance from some of the host nations, resulting in the chosen method of maritime prepositioning. This decision was also influenced by the fact that the United States had no bases in the region and prepositioning had already proven to be successful in Europe (Lee, 1999:9). The United States continued to negotiate with foreign countries for the location of prepositioning sites. Agreements were eventually reached with Egypt, Oman, Kenya, and Somalia for limited access to facilities (Linville, 1984:3). To this day, maritime and land-based prepositioning continues to supplement the forward base policy of the United States.

Mobility Triad

The United States has historically relied on the balanced capabilities of the mobility triad to provide mobility for its forces. As shown in Figure 6, this balanced capability consists of airlift, sealift, and prepositioning.

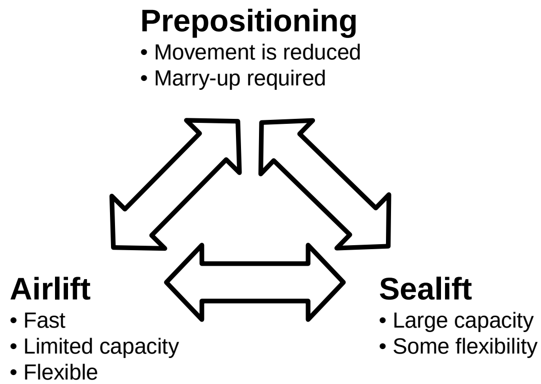


Figure 6. Balanced Capability for Force Protection

(Linville, 1984:2)

Each of the mobility assets makes a distinctive contribution to the total strength of the triad (Christie, 1992:44). Each has its own special strengths, but all are needed to provide balance mobility capability (Linville, 1984:2). Together, the triad provides for a global power projection capability. Over the course of a contingency, each element of the triad will significantly contribute to the build-up of forces. Figure 7 illustrates the concept of the mobility triad according to Army Field Manual 55-10.

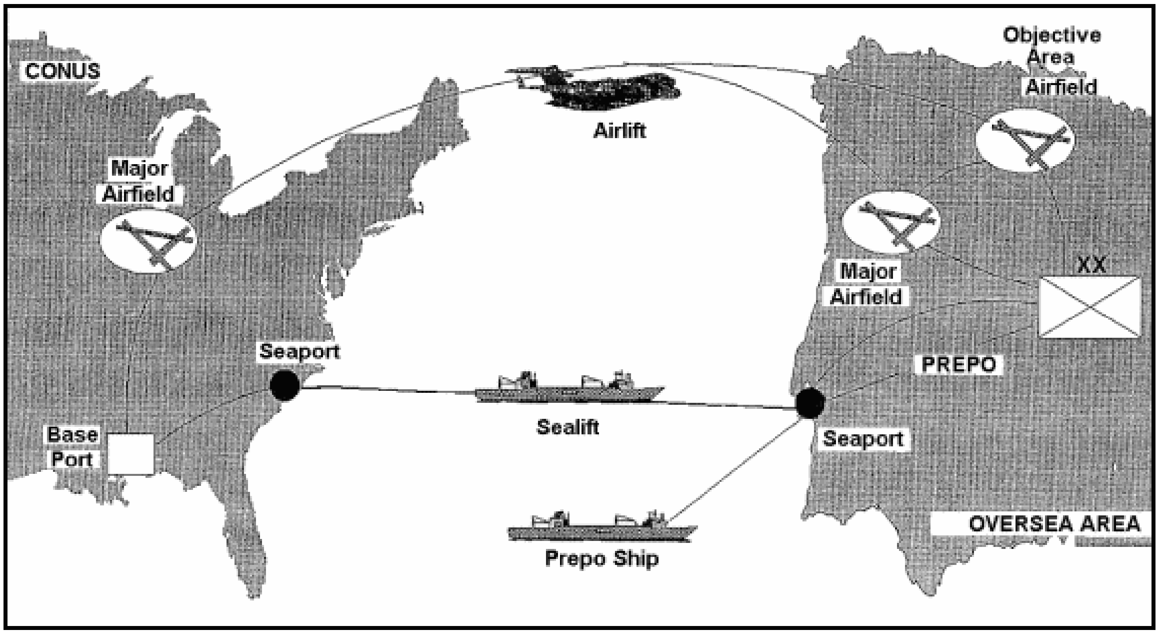


Figure 7. Mobility Triad

(FM 55-10, 1999)

Quick and agile, airlift is the most responsive method but is limited in the amount of capacity available. Sealift is the most robust capability and can deliver the majority of forces and supplies, but is not as responsive as airlift and prepositioning (Anderson, 1999:4). Prepositioning provides the necessary flexibility and surge requirements needed in a combat situation.

Effectiveness

Combat operations can only be successful with sufficient logistics support. Prepositioning, as an alternative to forward basing and total reliance on airlift, has proven to be an effective tool in providing that logistics support. Numerous studies have shown that prepositioning can be a critical link in the combat capability of forces.

In the late 1950s and 1960s, the RAND Corporation completed two studies comparing different combinations of prepositioning and airlift to provide rapid deployment capabilities for air forces in limited wars. The study from 1958 used costs and capabilities of the C-133 aircraft and the study from 1968 used costs and capabilities of the C-5 aircraft. The basic concept of both prepositioning and airlift remains the same today, thus the comparison of data within the studies is still applicable. The overall conclusion from both studies was that prepositioning is an effective means of providing combat support to forces. The 1968 study concluded:

> Comparing systems with and without prepositioning, the systems with prepositioning show advantages in most situations calling for large-scale quick-response capability (Fort, 1968:30).

In the mid 1980s another study was released by the RAND Corporation with the focus on improving the capability to project ground forces in SWA. This study also centered on the idea of an optimal mix of prepositioning and airlift:

> Our analysis suggests that although only prepositioning of equipment permits truly quick force deployment, each system has its drawbacks. A mix of systems designed to capitalize on the advantages and compensate for the drawbacks of each is most likely to result in an adequate capability for the United States (Dadant et al., 1984:x).

This study concluded that prepositioning must be included in contingency plans to give the United States the capability of a rapid response to a conflict in SWA (Dadant et al., 1984:147).

The first major test of the effectiveness of prepositioning in a modern combat environment came in 1991 with the Iraq invasion of Kuwait. Prepositioned stocks provided a massive, early supply of munitions and support equipment (Lund et al., 1993:7). Due to prepositioning, critical combat equipment was in theater within days.

This enabled airlift to concentrate on the movement of other equipment and troops directly from the United States and resulted in a joint force theater presence a full two weeks earlier (Doyle, 1996:8). In fact, an Air Force White Paper stated that the prepositioning investment guarantees operation from any location around the world. During Operation Desert Storm, the prepositioning of supplies saved an estimated 1,800 airlift missions and provided for the infrastructure of 21 principal airfields (White Paper, 1991:9). In the words of Lieutenant General Jimmy Ross, Army Deputy Chief of Staff for Logistics, "during Desert Shield, war reserve stocks literally saved us. I think it may change the way we do business in peacetime" (Kitfield, 1991:54).

A more recent RAND study established findings consistent with prior studies. This study focused on defense basing decisions and concluded that:

> The growing number of operations in locations around the world has led the AF to reconstitute itself as an expeditionary aerospace force (EAF). The EAF goal is to deploy forces anywhere in the world and begin sustained operations within 48 hours. However, such goals will be difficult to meet with current processes and technologies, particularly where resources are not prepositioned. This research has shown that forward support locations (such as the WRM storage facility at Sanem, Luxembourg) can aid the shift from surge to sustainment operations in a contingency when used for storage of WRM (Shlapak et al., 2003:106).

Advantages

Prepositioning offers a number of advantages over forward deployment. The successful use of prepositioning reduces manpower requirements overseas during peacetime. It also serves as a practical alternative to rapid force deployment from another theater, greatly reducing strategic airlift requirements (King, 1991:273). The equipment and supplies that have already been prepositioned do not have to compete for critical transportation. Airlift, while flexible and fast, is also expensive and limited in

capacity. Prepositioning allows available airlift to be dedicated to the movement of personnel and remaining items of combat forces (Linville, 1984:5). Furthermore, response time is significantly reduced, thus improving the capability to act quickly to acts of aggression. Deterrence is also an advantage of prepositioning. By committing equipment and supplies to certain regions of the world, the United States is able to display a sense of commitment to those regions.

Disadvantages

Prepositioning does have its disadvantages. A major weakness would be the vulnerability of prepositioned assets. In many cases, prepositioned sites are undefended against enemy attack. This allows for the possibility of equipment and supplies being susceptible to pilferage, sabotage, terrorism, and enemy attacks in time of hostilities (Franklin, 1986:33). Another disadvantage is the cost and maintenance of the facilities and the upkeep of the records. Without personnel readily available, facilities and records have a tendency to be overlooked. Finally, the prepositioning of equipment causes a duplication of that equipment for training purposes (King, 1991:273). This represents a major investment for the military. These relatively few disadvantages require careful consideration when considering prepositioning.

Airlift

Background

It is easy to forget, considering the impressive capabilities of modern air forces, that military aviation, in historical terms, is still in its infancy. The application of air power dates back only some 90 years. However, air power has established itself as an effective means of exerting military force. Versatility is one of the key advantages of air

power. Not only is an air force able to directly deliver firepower by air-to-air and air-to-surface weapons, but also is able to bring force to bear indirectly by escalating airlift operations to deploy combat units at high speed over great distances (Chapman, 1989:1). In any combat operation, time is of the essence once the decision has been made to engage in the conflict.

In 1964, Air Force Manual 1-1, United State Air Force Basic Doctrine, discussed airlift and its contribution to conventional warfare for the first time.

> Airlift contributes to rapid concentration of air and ground forces and resupply of tactical units in the field. In addition, long range or strategic airlift participates in the support of heavy logistics requirements. Air superiority is required for effective airlift, and close control is necessary for the efficient utilization of tactical airlift (AFM 1-1, 1964).

Airlift continues to play a vital role in the effectiveness of the power projection of the United States. The Air Force Doctrine Document 1 for 2003 states:

> Rapid global mobility refers to the timely movement, positioning, and sustainment of military forces and capabilities through air and space, across the range of military operations. Today, global mobility has increased in importance to the point where it is required in virtually every military operation. In theaters where only minimal forces are forward deployed, the value of global mobility is maximized since the key to successful contingency operations is the capability of the US to rapidly deploy forces to aid friendly nations. It is the particular competence of air and space forces to most rapidly provide what is needed, where it is needed (AFDD 1, 2003:97).

Airlift provides the ability to rapidly move personnel, equipment, supplies, and combat forces to anywhere in the world (AMMP2004, 2003:69). Since an enemy's advantage of surprise can be thwarted by a rapid response, airlift is an effective measure to accomplish force projection at the beginning of a conflict. Operation Desert Shield and Operation Desert Storm are good cases in point.

Operation Desert Shield/Storm

Since World War II, Operation Desert Storm was the largest airlift operation conducted by the United States. Airlift provided the means of moving critical assets rapidly, especially in the beginning of Desert Shield and in the period leading up to and into the war. By the end of the war, airlift had moved over 482,000 passengers and 513,000 tons of cargo into the theater. USAF C-5s and C-141s transported 72% of the air cargo and about 33% of personnel while commercial airlines moved the rest (White Paper, 1991:8). Within the theater, over 145 C-130s were generated and moved units forward as they deployed into the theater. In a span of 8 months, C-130s transported over 300,000 tons of cargo (White Paper, 1991:10). Even though the operational tempo was extremely high, airlift proved its flexibility in response to the Israel Scud missile attacks. The president ordered the delivery of Patriot batteries to Israel and the USAF responded quickly. Within 24 hours the first units arrived in country. The USAF diverted may of its C-5s and C-141s from other missions to support this requirement. The entire deployment of the Patriot batteries was completed in a matter of days. This experience highlighted the innate flexibility of airlift and the considerable contribution it can make in a rapidly changing operational environment. Throughout the war, unexpected requirements such as this one meant that airlift was constantly in demand (Lund et al., 1993:18). To meet this demand on airlift operations, it was necessary to activate the Civil Reserve Air Fleet (CRAF).

CRAF

With most of the military's 284 C-5 and C-141 aircraft used for the operation almost immediately, Operation Desert Storm was the first time in 38 years that CRAF

was activated (Kitfield, 1990:38). CRAF provides a significant part of AMC's mobility resources. CRAF augments passenger, cargo airlift, and air evacuation in a contingency or war and consists of commercial passenger and cargo aircraft voluntarily pledged by commercial carriers. Three stages of activation allow for tailoring of a suitable airlift force during a contingency. Stage I is for minor regional crises, Stage II is for major theaters of war, and Stage III is used for national mobilization. Each stage of CRAF is only used to the extent necessary to effectively augment Department of Defense (DoD) operations (Air Force Fact Sheet, 2004). On 18 August 1990, the first stage of CRAF was activated. This stage consisted of 18 passenger and 23 cargo aircraft. Once the fighting actually started, the second stage of CRAF was activated, which consisted of an additional 77 passenger and 40 cargo aircraft. These commercial carriers provided the additional airlift needed to meet the wartime requirements (White Paper, 1991:8). Table 2 shows a complete breakdown of missions flown for Operation Desert Shield and Operation Desert Storm from August 1990 to February 1991.

Table 2. Missions Flown by Aircraft Type and by Month

Type	Aug-90	Sep-90	Oct-90	Nov-90	Dec-90	Jan-91	Feb-91	Total
Organic								
C-5	397	510	437	416	570	680	552	3,562
C-141	967	998	682	710	1,399	1,639	1,457	7,852
KC-10	17	88	55	50	115	48	0	373
Organic Subtotal	1,381	1,596	1,174	1,176	2,084	2,367	2,009	11,787
CRAF								
Narrow Body: Cargo	60	86	45	91	154	289	346	1,071
Narrow Body: PAX	3	9	8	9	11	40	47	127
Wide Body: Cargo	21	93	51	71	112	200	279	827
Wide Body: PAX	88	121	145	44	281	246	109	1,034
CRAF Subtotal	172	309	249	215	558	775	781	3,059
Total	1,553	1,905	1,423	1,391	2,642	3,142	2,790	14,846

(Lund et al., 1993:9)

Capabilities

Air mobility supports the National Security and Military Strategies throughout the field of conflict, from peacetime operations for global interests to commitments in major theater wars. Rapid power projection is essential to the military in the establishment of a secure presence. Cargo airlift is key to air mobility force capability (AMMP2004, 2003:7). In terms of cargo aircraft, AMC's force structure is shown in Table 3. AMC uses all of these assets to deliver rapid, global air capability.

Table 3. AMC Airlift Force Structure

Weapon System	Current Inventory	Projected Inventory
C-5	126	126
C-141	100	0
C-17	80	180
KC-135*	545	545
KC-10*	59	59
*Dual Role = Cargo + Refueling		

(Air Force Handbook, 2002)

The total requirement for airlift is determined through a Mobility Requirements Study. Two such studies have recently been completed: the 1995 MRS Bottoms-Up Review Update (BURU) and the Mobility Requirements Study FY2005 (MRS-05). These studies set the minimum requirement airlift capability (and subsequently updated it) to meet national objectives in peace and war. Airlift requirements are computed in terms of millions of ton-miles per day (MTM/D) which is the standard unit of measure of airlift capacity. The recently released MRS-05 established a minimum intertheater airlift requirement of 54.5 MTM/D at a moderate risk level. Figure 8 illustrates airlift

capabilities compared to requirements (AMMP2004, 2003:73). The results of MRS-05 are notably higher than the 49.7MTM/D requirement identified by the 1995 MRS BURU. However, current capacity does not meet the identified requirement for a single major theater war (MTW). In 1995, the available capacity was 11 percent short of the minimum requirement of 49.7 MTM/D (Hazdra: 2000, 34). Based on the information in Figure 8, AMC still has a shortfall (13 percent shortage against the new MRS-05 target). This fact was verified in the Air Mobility Master Plan 2004, "the current capacity falls far short of supporting the warfighter alone; and 54.5 MTM/D is the minimum level of capacity that assures moderate risk in a single major theater war (MTW). When constraints regarding warning time, National Command Authority decision-making, CRAF activation, levels of allied support, and warfighting timelines are relaxed from their very optimistic levels, risk drives the intertheater airlift solution above 67.0 MTM/D" (AMMP2004, 2003:74). Further, it is important to realize that the total capacity of Air Mobility Command's airlift capability includes a constant 20 MTM/D non-organic capacity supported via the CRAF. In short, the requirement set by MRS-05 is based on multiple optimistic assumptions and there are significant shortfalls in the available capacity identified to support that requirement.

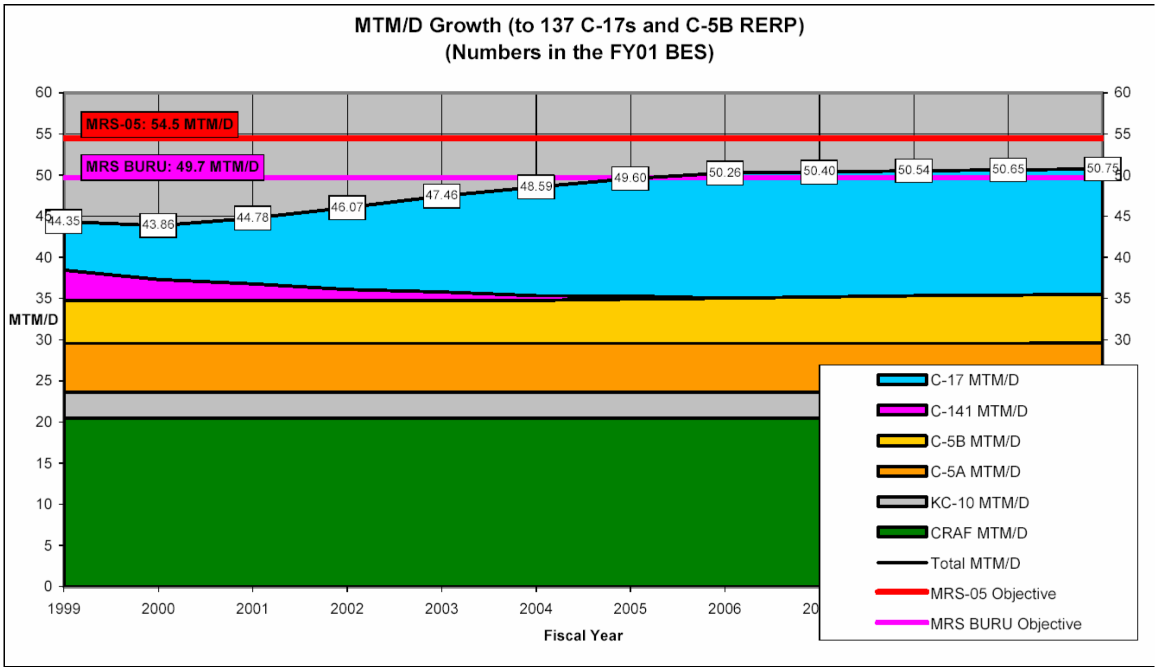
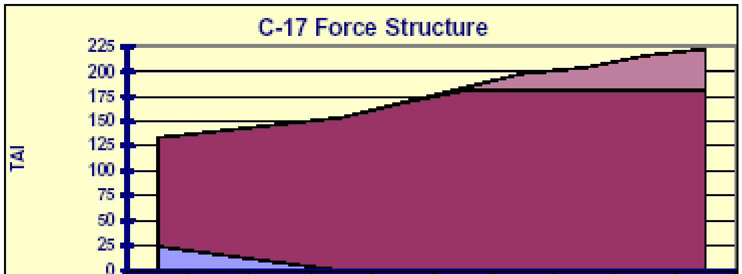


Figure 8. **Airlift Capability vs. Requirements**

(AMSP2002, 2002:64)

The C-17 has proven to be an exceptional aircraft and, combined with the C-5 fleet, provides the nation's long-range cargo airlift capability. However, a significant shortfall in meeting airlift requirements still exists (AMMP2004, 2003:73). Closing the delta between required and available capacity is being addressed through procurement of new aircraft and modification of existing aircraft. Air Mobility Command has aggressively pursued replacement of the aging C-141 fleet with new C-17s. Figure 9 shows the phase in and phase out C-141 and C-17's respectively. Budget preparations for the Fiscal Year Defense Program accommodate the procurement of AMC's programmed number (180) of C-17s through FY08.



	04	05	06	07	08	09	10	11	12	13
C-17 (222)	0	0	0	0	0	3	18	23	36	42
C-17 (180)	109	124	139	154	168	180	180	180	180	180
C-141	24	16	8	0	0	0	0	0	0	0

Figure 9. C-17 Force Structure

(AMMP2004, 2003:127)

AMC is also targeting the poorest performing C-5 aircraft systems for a comprehensive modernization effort. C-5 systems reliability, maintainability, and supportability are in decline as operating costs increase. The two modernization programs that will address the C-5 problems are the Avionics Modernization Program (AMP) and the Reliability Enhancement and Reengineering Program (RERP) (AMMP2004, 2003: 111). AMP will replace low reliability avionic components and RERP will improve poor reliability, maintainability, and availability performance. Figure 10 shows the modification timeline. Upon completion of the modifications, the airplane will be designated the C-5M (AMMP2004, 2003:110).

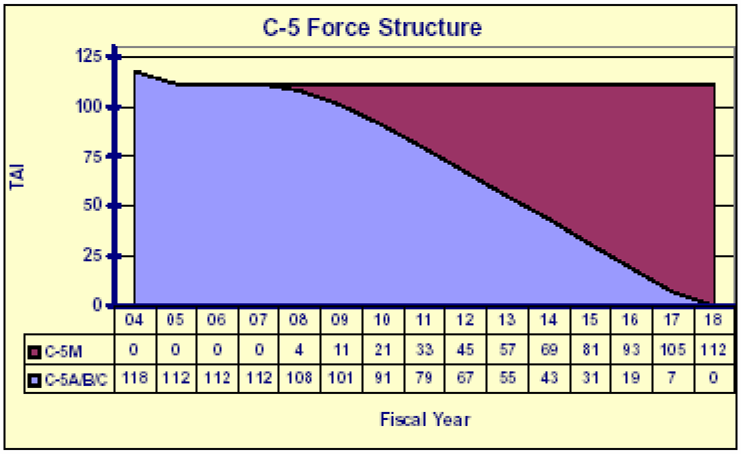


Figure 10. C-5 Force Structure

(AMMP2004, 2003:111)

The AF is currently funded to replace 270 C-141s with 180 C-17s and is living with a fleet of C-5s that is unable to meet the wartime mission capable rate of 75%. To provide the necessary 54.4 MTM/D it seems that the solution must be a combination of the additional C-17s and the modifications to the C-5s. The AF needs to increase the size of the C-17 fleet from the currently programmed number of 180 to 222. The preferred force structure is a mix of an appropriate number of modernized C-5s to maintain a viable C-5 fleet with its unique capabilities and a minimum of 222 C-17s to meet the broad range of missions the combatant commanders require. AMC's recommendation is to start the RERP with the C-5Bs and then commence a reliability and maintainability evaluation before continuing with the modification on the C-5As (AMMP2004, 2003:74). Table 4 illustrates the alternatives proposed by MRS-05.

Table 4. Mobility Requirements Study 05 Alternatives

C-5 and C-17 Comparison for MRS-05 Requirements						
# of C-17s	C-5B UnRERPed	C-5B RERPed	C-5A UnRERPed	C-5C RERPed	C-5A Retired	MTM/D
180	0	50	60	2	14	55
222	0	50	0	2	74	55

(AMMP2004, 2003:74)

Despite the Air Force's efforts to close the gap between requirements and available capacity, there is still considerable risk in failing to meet mission requirements. Specifically, the MRS-05 solution is optimistic as it assumes perfect command and control, perfect scheduling, no broken airplanes congesting the system, and no delays for weather, air traffic restrictions, political clearances, or airfield operating hours (AMMP2004, 2003:74).

Summary

This chapter exposed the reader to some of the existing literature on the subjects of ABDR, prepositioning, and airlift. Experiences in the field of ABDR and the evolution process utilized to reach current ABDR practices were discussed. The chapter then explored the concept of prepositioning, including its history and overall effectiveness. Finally, the chapter concluded with a review of airlift capability and current shortfalls. The next chapter presents the methodology used to conduct this research.

III. Methodology

Overview

This chapter describes the methodology used to conduct the research. It will describe the case study design and demonstrate why it is appropriate for this study. The chapter will also include the methods for data collection and analysis.

Method

Yin suggests that the case study is "the preferred strategy when "how" or "why" questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context" (Yin, 1994:1). Yin goes on to identify that three conditions should be considered when choosing a research strategy: 1) the type of research question posed, 2) the extent of control an investigator has over actual behavioral events, and 3) the degree of focus on contemporary as opposed to historical events (Yin, 1994: 4). Yin's criteria for choosing the case study approach for the research strategy is shown in Table 5. The current research entails an exploratory question being asked about a contemporary phenomenon of which the researcher has no control.

A case study can involve either single or multiple cases, and can involve numerous levels of analysis. After the literature is used to explain the ABDR trailer prepositioning program, this study will use a multiple case study methodology to explore the movement of ABDR trailers in a war environment. The areas of ABDR, prepositioning, and airlift will be the three cases used to investigate and understand the movement of the ABDR trailers. Defining the initial research questions and selecting the

cases to be studied specifies the organizations to be approached, the kind of data to be gathered, and the relevant population (Eisenhardt, 1989:533).

Table 5. Relevant Situations for Different Research Strategies

Strategy	Form of research question	Requires control over behavioral events?	Focuses on contemporary events?
Experiment	how, why	yes	yes
Survey	who, what, where, how many, how much	no	yes
Archival Analysis	who, what, where, how many, how much	no	yes/no
History	how, why	no	no
Case Study	how, why	no	yes

(Yin, 1994:6)

This research seeks to address questions of “how” and “what.” “How” questions are generally explanatory in nature and are likely to lead to the use of a number of research strategies to include the case study. This is because “how” questions deal with operational links needing to be traced over time rather than frequencies or incidence (Yin, 1994:6). In contrast, there are two types of “what” questions: exploratory, where the goal is to develop pertinent propositions for further inquiry which can be used for any of the research strategies; and the “what” question in the form of “how much” or “how many” which favor survey and archival strategies (Yin, 1994:5). The “how” questions presented in this research are explanatory and the “what” question is exploratory. Based upon these criteria and given the nature of the research questions the case method appears to be the most applicable.

<u>Form of Research Question</u>. As stated in chapter 1, the purpose of this research is to determine if the USAF should continue to use prepositioned ABDR trailers to augment

strategic airlift during combat operations. Once the scope and purpose of this research were defined and captured in the stated research question, investigative questions were developed to further narrow the investigation of the topic. Those investigative questions are:

- How has ABDR historically provided mission support?
- How does the ABDR function provide mission support in today's operational environment?
- How does the current method of prepositioning ABDR trailers in strategic locations throughout the world meet time requirements in wartime situations?
- What support does airlift, assuming trailers are not prepositioned, provide for ABDR capability in a wartime environment?

Extent of Control. Yin states that a further distinction presented by the case study method is the extent of the researcher's control over actual behavioral events (Yin, 1994:8). The study of the current method of prepositioning ABDR trailers deals with events that cannot be changed by the researcher due to the researcher not being in a position of authority concerning ABDR practices. The research is not an experiment and the researcher has no control over actual behavioral events in the current research. However, this research will provide documentation to assist in the decision-making process. The criteria for extent of control are met.

Degree of Focus. In examining contemporary events, the case study method is preferred but only when the relevant behaviors cannot be manipulated. Compared to the history strategy, where there are no relevant persons alive to report, the case study method uses systematic interviewing while taking care to avoid manipulating individuals'

behavior. The case study method relies on many of the same techniques as the history strategy, however a unique strength of case studies is their ability to deal with a variety of evidence types such as documents, artifacts, interviews, and observations (Yin, 1994:8). Given the focus of this research is on a contemporary event as opposed to a historical event, the criteria for the degree of focus are met.

Research Design

The research design is a logical plan for getting from the initial set of questions to a set of conclusions (Yin, 1994:19). The design of the research is critical in determining what questions should be addressed, what data are relevant, the type of data to collect, and how to analyze the data. There are five components of a research design: research questions, propositions, units of analysis, logic linking the data to the propositions, and criteria for interpreting the findings (Yin, 1994:20).

Research Question. As previously stated in this chapter, the research question in this study can be addressed through case research. Additionally, the exploratory question being asked about a contemporary set of events over which the researcher has no control is appropriate to address through the case study methodology (Yin, 1994:5).

Research Propositions. Stating one or more propositions moves the researcher in the right direction and will tell the researcher where to look for relevant evidence. The research propositions present the purpose of the research. It is necessary for the propositions to address what the study proposes (Yin, 1994:21). The purpose of this particular research is to present research findings that will facilitate decisions made about the prepositioning of ABDR trailers. To help focus data collection for this study, it is

necessary to link the propositions with the applicable investigative question. The propositions and related investigative question are as follows:

- o ABDR trailer availability affects readiness in combat operations
    - o How has ABDR historically provided mission support?
    - o How does the ABDR function provide mission support in today's operational environment?
- o Prepositioning presents advantages in time sensitive delivery
    - o How does the current method of prepositioning ABDR trailers in strategic locations throughout the world meet time requirements in wartime situations?
- o Prepositioning provides an effective alternative to airlift
    - o What support does airlift, assuming trailers are not prepositioned, provide for ABDR capability in a wartime environment?
    - o How does the current method of prepositioning ABDR trailers in strategic locations throughout the world meet time requirements in wartime situations?

These propositions were developed to focus data collection to certain areas while developing the case studies, more specifically to areas of research that are relevant to the overall study.

Unit of Analysis. The unit of analysis defines what an actual "case" is (Yin, 1994:21). From a macro view, the unit of analysis for this study is the ABDR trailer prepositioning program. This approach provides an umbrella covering the three major aspects of the program; ABDR, prepositioning, and airlift. A more in-depth look at each

research question reveals that the unit of analysis is dependent on the specifics of the question. The first two questions deal with the ABDR program and how the USAF has utilized ABDR in the past and how ABDR is implemented in modern warfare. These questions are answered using qualitative data derived through content analysis of various DoD publications. The remaining two questions pertain to the applicability of both prepositioning and airlift. These questions are addressed using qualitative data derived through content analysis of various DoD publications along with data from correspondence. Quantitative data consisting of response time analysis of both prepositioning and airlift mission requirements is also used.

Logic Linking Data to the Propositions. The development of converging lines of inquiry is a result of using multiple sources of evidence (Yin, 1994:92). Data for case studies can come from many sources with six of the most important being documentation, archival records, interviews, direct observations, participant-observation, and physical artifacts (Yin, 1994:78). Documentation in this research includes reports, studies, and theses previously accomplished in the areas of ABDR, prepositioning, and airlift. Archival records consist of system descriptions as found in DoD publications containing data relating to service and organizational records. Interviews of key members will be conducted as necessary to clarify areas of uncertainty. These various sources are highly complementary and a good case study will want to use as many sources as possible (Yin, 1994:80).

Criteria for Interpreting the Findings. Data collected through case study research may be hard to analyze because the strategies and techniques are not always well defined. Yin details two strategies to complete the analytic phase of the research successfully:

relying on theoretical propositions and developing a case description (Yin, 1994:103). The preferred strategy is to follow the theoretical propositions; however, in the absence of propositions, the case description will be used (Yin, 1994:103). Since propositions have been developed, this study will rely on theoretical propositions as opposed to developing a case description. The propositions can shape the data collection plan and give priorities to relevant analytic strategies (Yin, 1994:104). By relying on theoretical propositions, the researcher will be able to focus attention on relevant data only.

Quality of Research Design

Four tests help to establish the quality of any empirical social research: construct validity, internal validity, external validity, and reliability. Because the case study is a form of empirical research, these four tests are considered applicable to case study research (Yin, 1994:32). The four widely used tests, the tactics used in this research to address the test, and the phase of the research the tactics are used are shown in Table 6.

Table 6. Adapted from *Case Study Tactics for Four Design Tests*

Tests	Case Study Tactic	Phase of research tactic is used
Construct Validity	• Use multiple sources of evidence • Establish chain of evidence • Have key informants review draft of case study report	Data collection Data collection Composition
Internal Validity	• Pattern matching • Cross check findings with key informants	Data analysis Data analysis
External Validity	• Compare findings to theory in literature	Data analysis
Reliability	• Full documentation of processes and procedures	Composition

(Yin, 1994:3)

Credible research should seek to maximize construct validity, internal validity, external validity, and reliability. Validity affects the appropriateness, meaningfulness, and usefulness of the specific inferences made from the measures. Reliability deals with the degree to which observed scores are free from errors of measurement (Dooley, 2001:76).

Construct Validity. Construct validity is defined as "establishing correct operational measures for the concepts being studied" (Yin, 1994:33). Three tactics are used to enhance construct validity: multiple sources of evidence, establish a chain of evidence, and have the case study report reviewed by key informants (Yin, 1994:35). Research that has construct validity encourages convergent lines of inquiry, which is relevant during data collection (Yin, 1994:34).

Internal Validity. Internal validity is described as "the accuracy of the information and whether it matches reality" (Cresswell, 1994:158). Several tactics can be used to help increase internal validity but this research utilizes only two. Research that is able to identify coinciding patterns strengthens internal validity (Yin, 1994:106). Presentation of categories or themes to key informants will determine the accuracy of conclusions (Cresswell, 1994:158). Accomplishment of pattern matching in the analysis of the data and a cross check of the findings with key informants at the completion of the study will satisfy the requirement for internal validity.

External Validity. External validity is defined as "establishing the domain to which a study's findings can be generalized" (Yin, 1994:33). Research that is externally valid generalizes a particular set of results to some broader theory (Yin, 1994:36). Analysis of multiple cases aids in the discovery of any replication of phenomena across

cases. This research increases external validity by comparing the findings in this study to theory in literature.

Reliability. Reliability is defined as "demonstrating that the operations of a study can be repeated with the same results" (Yin, 1994:33). Research that is reliable has the ability to enhance the study's chance of being replicated in another setting. Furthermore, reliability will minimize any errors and biases in a case study (Yin, 1994:36). A case study database will ensure the final quality criterion of reliability.

Data Collection

As previous discussed, Yin identifies six sources of evidence that are used in case studies: documents, archival records, interviews, direct observation, participant-observation, and physical artifacts (Yin, 1994:78). In this case study, official documentation, archival records, and interviews serve as sources of evidence. When conducting case studies, there are other important principles to go along with the attention given to these individual sources. These principles include the use of multiple sources of evidence (evidence from two or more sources but converging on the same set of findings, thereby increasing validity), a case study database to assemble evidence distinct from the final case study, and a chain of evidence (links between the question asked, the data collected, and the conclusion drawn). The quality of case study research increases significantly with the inclusion of these principles (Yin, 1994:78).

In addressing Yin's first principle of multiple sources of evidence, data was extracted from numerous sources as stated earlier in this chapter in the section of "Logic Linking Data to the Propositions." Triangulation, which is the rationale for using

multiple sources of evidence, provides for convergent validity which produces more convincing and precise findings (Yin, 1994:92).

Yin's second principle of a formal database of evidence distinct from the final case study report is outside the scope of this research due to the issue of redundancy. The ABDR PO literature collection fits this principle. The ABDR PO contains an enormous wealth of information from hundreds of sources.

Yin's third principle of a chain of evidence that links the questions asked, data collected, and conclusions drawn are laid out in the investigative questions asked in chapter one, the findings in chapter four, and the conclusions and recommendations in chapter five.

Data collection began with research into documents related to ABDR, prepositioning, and airlift. This research was conducted by meeting with the ABDR PO and searching a number of research databases. Searches uncovered a number of documents including instructions, regulations, procedures, and historical records. The research also led to many different theses and studies that covered the applicable areas of ABDR, prepositioning, and airlift. The collection of this data led to the formulation of multiple cases covering the areas of ABDR, prepositioning, and airlift. The next step was to conduct interviews with various individuals with experience and responsibilities in the subject area. All of the interviews were conducted in an informal manner through telephone and e-mail correspondence.

As discussed earlier, the research design dictates the necessity of utilizing the propositions to help focus data collection. In this instance, the propositions directed the

researcher to specific agencies capable of answering the investigative questions. The specific agencies and the related propositions are as follows:

- ABDR PO at Wright Patterson AFB, Ohio
    - ABDR trailer availability affects readiness in combat operations
    - Prepositioning presents advantages in time sensitive delivery
    - Prepositioning provides an effective alternative to airlift
- AMC Airlift Analysis Branch at Scott AFB, Illinois
    - Prepositioning presents advantages in time sensitive delivery
    - Prepositioning provides an effective alternative to airlift

Data Analysis

Data analysis consists of examining, categorizing, and tabulating the evidence to address the propositions of a study. One of the most difficult and least developed aspects of doing case studies is analyzing the data. To combat this, much depends on the researcher's style of rigorous thinking (Yin, 1994:102). Statistical analysis is not necessarily used in all case studies. Instead, the researcher relies on experience and literature to present the evidence in various ways (Tellis, 1997). The case study method typically involves the following steps adapted from Leedy and Ormrod (2001:150).

1. *Organization of details about the case*- specific facts about the case are arranged in chronological order.

2. *Categorization of data*- categories are identified that can help gather data into meaningful groups.

3. *Interpretation of single instances*- documents, occurrences, and other bits of data are examined for specific interpretations that they might have in relation to the overall case.

4. *Identification of patterns*- the data and their interpretations are scrutinized for other patterns that characterize the case more broadly.

5. *Synthesis and generalizations*- an overall portrait of the case is constructed.

The objective of this research is to identify the best process for ABDR trailer positioning for wartime response and use. This study consolidated all of the information gathered from multiple sources to understand the purpose of ABDR, prepositioning, and airlift. The data was categorized and patterns were identified to assist with the development and analysis of multiple cases. Generalizations were extracted from the literature review and provided the answers for the first two investigative questions. The next two questions were answered by conducting content analysis of data gathered from official documentation and interviews, along with a time comparison of prepositioning and airlift. This analysis of the evidence led to the researcher developing conclusions and recommendations, which are presented in chapter five.

Summary

This chapter presented a description of the methodology chosen for this research. Justification for choosing the case study method, the research design, the quality of the research design, and the data collection and analysis techniques were discussed. The following chapter will document the results of this methodology. Through analysis of the findings documented in chapter four, the researcher hopes to identify common themes useful in presenting recommendations and conclusions in chapter five of this research.

IV. Analysis

Overview

The results of the data gathered for this research and an analysis of the information are presented in this chapter. This research examines if the AF should continue to use prepositioned ABDR trailers to augment strategic airlift during combat operations. To accomplish this, the researcher evaluated numerous documents and archival records, and used information collected from key personnel through correspondence and interviews to present a delivery time comparison.

The first section of the literature review in chapter two discussed the history of ABDR, from World War I to Operation Desert Storm, and its relative impact on combat operations. It then discussed the development of the ABDR program, its current posture, and how it provides mission support in today's operational environment. To answer investigative question one and two, the researcher was required to conduct an analysis of the literature and clarify areas of uncertainty through interviews and correspondence with ABDR experts.

The second section of the literature review discussed the concept of prepositioning, to include its history, effectiveness, advantages, and disadvantages. Investigative question three is answered through analyzing data gathered in the literature and data gathered in interviews and correspondence with key personnel in the prepositioning field. Furthermore, an analysis of delivery time is conducted based on subject-matter expert inputs.

The final section of the literature review discussed the function of airlift and its role in warfare environments. The literature in this section assists with the task of answering investigative question four. Interviews, correspondence, and review of official documents are also used in answering this question along with an analysis of delivery time based on inputs from subject-matter experts.

The primary objective of this chapter is to provide the details necessary to reveal the conclusions drawn by the researcher presented in chapter five of this work.

Investigative Question One

How has ABDR historically provided mission support?

As previously discussed in chapter two, the first signs of ABDR use date back to when aerial combat was first encountered. The United States was ill prepared for air warfare because the Army did not see aviation as an important part of the war effort in World War I. The Air Service consisted of only about 100 pilots and 125 airplanes. The aircraft that were available were in poor condition due to heavy use and spare parts shortages. The first recorded cases of damage repair occurred at this time when airmen used discarded French farm machinery to repair aircraft (Voyls, 1983:1).

As World War II approached, the United States' airpower was hardly better off than it was at the beginning of World War I. During World War II, the allied air forces were at a numerical disadvantage and came to realize that every aircraft was a valuable asset. The United States and its allies were not able to establish air superiority at the beginning of the war (Holcomb, 1994:10). Military leaders began to think favorably about the use of airpower, primarily due to the effective use the British made of its airpower early in the war (Voyls, 1983:2). The British made superb defensive use of its

limited fighter strength against the German Luftwaffe, which was twice the size, during the Battle of Britain. The RAF was able to counter with the necessary aircraft due to the repair of damaged aircraft on the spot. For the United States, the true concept of ABDR was born as every effort was made to quickly repair its damaged aircraft and return them to flying status. Maintainers learned different repair techniques that drastically reduced aircraft repair times. In response to a slow supply line, some maintainers found they also had to fabricate suitable substitute parts and develop their own took kits (ABDREH, 1996:2).

In the Vietnam War, most of the damaged aircraft were returning to their base of origin and maintenance personnel were not able to keep pace with the high repair tempo (ABDREH, 1996:3). Aircraft were operating in close support and interdiction roles, and were flying high sortie rates. Repairing damaged aircraft required using whatever materials and equipment were available. The AF was not organized to sustain a rapid repair mission, resulting in an adverse effect to operational readiness. To combat this, in 1965 the AFLC authorized the formation of RAM teams (Diamond and Luthor, 1991:xv). The RAM teams consisted of highly trained personnel from all five of the ALCs in existence. During the Vietnam War, more than 1000 aircraft were repaired by RAM teams mobilized by AFLC (Diamond and Luthor, 1991:xvi). Contributing to the success of the RAM teams was that the personnel were expertly trained in accelerated repairs and AFLC was able to maximize the supply line to support the increase in requests for parts and supplies. ABDR tool kits became more uniform, resulting in consistent repairs. However, the deployment of the RAM teams was not responsive enough in a combat environment (Moseley, 1988:5). This concern led to the development of the CLSS.

The CLSS was designed to provide support in the areas of maintenance, transportation, and supply. The primary repair activities for ABDR were shifted to operational maintenance and augmentation was supplied by the CLSSs. All of the military personnel previously assigned to a RAM team were now assigned to a CLSS. Operational units utilized their individual tool kits coupled with special tooling used by the former RAM teams and controlled by the ALCs (Huff, 2003).

The Israeli Air Force benefited from an effective ABDR capability during the Yom Kippur War. The goal of the Israeli ABDR program was to repair as many aircraft as possible at the field level due to time constraints and the limited resources available. Maintenance personnel, along with ABDR specific tools and equipment, were integrated into the operational maintenance units. The Israeli Air Force was able to perform many permanent fixes on damaged aircraft even though the objective was rapid repair. Permanent fixes were made possible because engineers were in the field at all times, because of the availability of proper tool kits, and the relatively short supply lines (McMahon, 1986:15).

The British developed their own official ABDR program based largely on lessons learned through studying IAF actions during the Yom Kipper War. The British were not able to validate the program until the Falkland War in 1982. During this war, every RAF Harrier committed to the conflict was repaired in some form at least once (Peecook, 1991:48). Based on their success, the British identified fourteen principles, listed in chapter two, relevant to future success of an ABDR program (McMahon, 1986:19). The tenth principle, “Kits are essential,” concluded that the RAF realized the criticality of tool

accessibility for its ABDR teams and its importance in the development of an effective ABDR program.

Operation Desert Storm saw the United States demonstrate a successful ABDR capability. A total of forty-two CLSS ABDR teams deployed in support of Operation Desert Storm to augment maintenance operations and provide rapid repair capability to the flying units (Coyne, 1992:133). Many different type of aircraft were damaged and repaired, with the bulk of the damage being suffered by A-10 aircraft. Twenty-six battle damage incidents were reported with around 50% of the damages being repaired within 24 hours. ABDR teams in the Gulf War provided support to many different types of aircraft, including A-10s, F-15s, F-16s, B-52s, and C-130s. This support was facilitated by the fact that the ABDR teams possessed the proper tools and equipment.

The historical relationship between lost and damaged aircraft is that for every aircraft lost, up to five aircraft return with some type of damage requiring repair. Predictions for future engagements have shown that in some scenarios the rates could be as high as twenty aircraft damaged to one lost (Srull et al., 1991:2). Experience has shown that the capability to rapidly repair combat damage is vital to the ability to maintain wartime aircraft availability and sortie rates. Resources will be constrained to what is available at the onset of hostilities. There will be little, if any, opportunity to train new people or supply new tools. Thus, it is important to have the capability to maximize the potential of the resources on hand at the beginning of any conflict.

Ingenuity will play a large role in the actual repair process of ABDR. Every battle-damaged aircraft will probably require a different approach to make the repairs. The actual repair is where ABDR differs from normal maintenance repair actions.

History has shown that the possibility of battle-damaged aircraft makes it imperative that a deployed CLSS has an established ABDR capability upon arrival at the deployed location. This capability is improved with the immediate presence of the ABDR trailers at the start of hostilities.

Investigative Question Two

How does the ABDR function provide mission support in today's operational environment?

CLSSs play a crucial role in weapon system sustainment. Combat logistics support forces provide AF commanders with dedicated, flexible, and mission-ready military ABDR maintenance support. These ABDR teams offer specialized logistics capabilities in direct support of AF operations (AFMCI 10-202, 2001:8). CLSSs provide worldwide teams which deploy to perform all aspects of ABDR and also assist the organization where possible with scheduled and unscheduled standard or heavy maintenance. When these teams are not deployed, they assist the Air Logistics Center directorates in performing depot-level maintenance and aircraft modifications at various depots (Kitchens, 1997:5). CLSSs are functionally aligned under the ALC commander and are organized using the chart in Figure 11. The ABDR function falls within the aircraft element in the maintenance flight.

AFMC inherited the ABDR Program Management Office (PMO) and all the CLSSs in 1992. The ABDR PMO was later renamed the ABDR Program Office and responsibilities where subsequently modified. The CLSS functional manager at HQ AFMC/LG is the process owner for the ABDR function (Johnson, 2003). Responsibilities of the ABDR PO include development of databases and technical

information, providing technical support to the AFMC laboratories and system program offices, and management of the ABDR trailers (AFMCI 10-202, 2001:7).

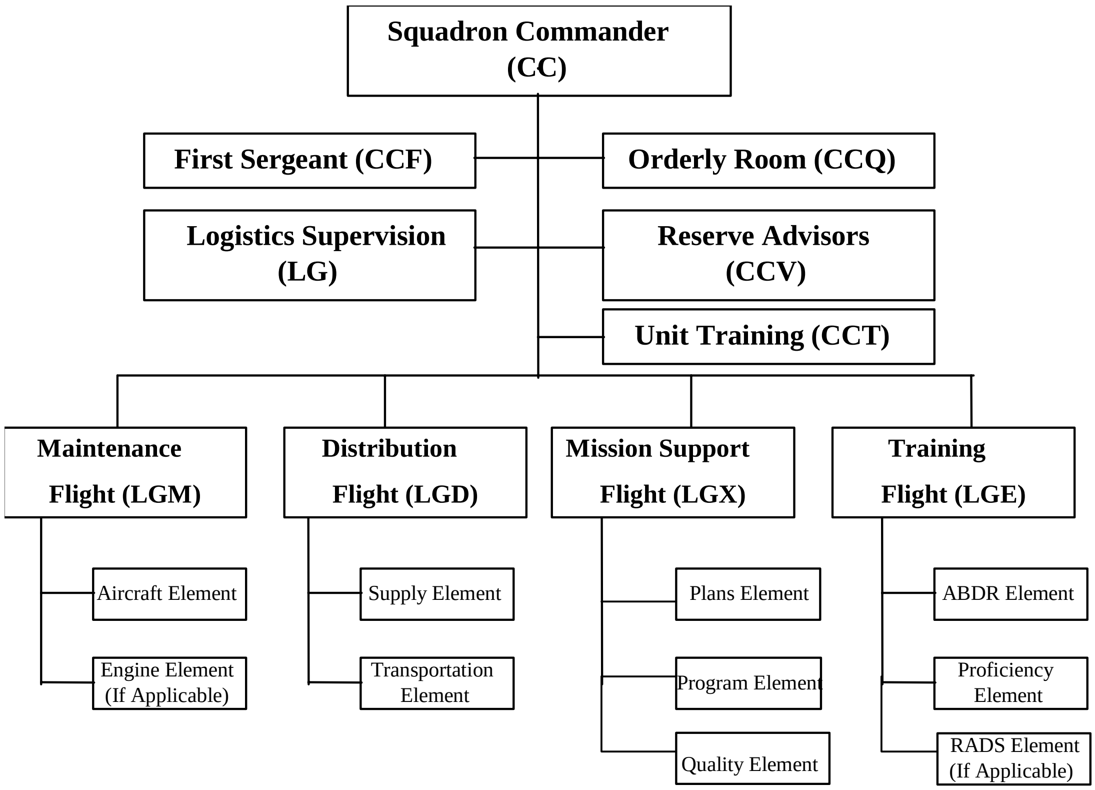


Figure 11. CLSS Organizational Chart

(AFMCI 10-202, 2001:9)

In 1995, the AF changed the ABDR policy by eliminating the requirement for operational units to have an ABDR program and gave the primary responsibility to AFMC and the CLSSs. This change was driven by the lean logistics environment and redefined how the AF would do ABDR in a post-Cold War era to support the two major theater war scenario. Moving the responsibility for ABDR to AFMC was done to eliminate duplicate ABDR programs and take a leaner approach to the traditional ABDR

philosophy. The number, types, and size of teams were changed to meet the new demands (elimination of the organic capability) of a changing AF (CLSSMP, 2001:22). Table 7 reflects current team numbers, types, and sizes.

Table 7. Current CLSS Active/Reserve Repair Teams

MDS	PAA		ENL REQ'D	ACTIVE TEAMS	TOTAL ACTIVE	AFRES TEAMS	TOTAL AFRES	TOTAL TEAMS	TOTAL PER
A-10	18	ABDR	15	4	60	6	90	10	150
B-52	14	ABDR	14	1	14	1	14	2	28
B-1	14	ABDR	14	1	14	1	14	2	28
C-130	16	ABDR	14	7	98	11	154	18	252
F-117	18	ABDR	13	2	26	0	0	2	26
C-17	16	ABDR	8	4	32	0	0	4	32
AFSOC		APOD	14	0	0	0	0	0	0
C-5		APOD	11	1	11	4	44	5	55
KC-135	10	ABDR	14	1	14	3	42	4	56
C-141		APOD	7	2	14	2	14	4	28
HH53/60	24	ABDR	7	3	21	0	0	3	21
F-15	18	ABDR	14	5	70	8	112	13	182
F-16	18	ABDR	13	10	130	17	221	27	351
B-2	8	ABDR	14	1	14	0	0	1	14
			TOTAL	42	518	53	705	95	1223

(CLSSMP, 2001:23)

During wartime, CLSS forces are organized into standard and nonstandard force packages, commonly referred to as a UTC. Response times are 24-hours for active duty and 72 hours for reserve teams, respectively. Team sizes and personnel skills are tailored, as required, to meet mission requirements. Deployed teams are dependent on available facilities and require base operating support. Teams can also be redeployed to other locations to meet new mission requirements (Johnson, 2003).

In peacetime, CLSS forces are "organized into short-term logistic support teams. More specifically, maintenance personnel are organized into depot field teams that

provide technical assistance or perform specified maintenance and modification tasks on aircraft, aircraft engines, or aerospace equipment" (AFMCI 10-202, 2001:16).

The ABDR teams provide aircraft battle damage assessment and repair on aircraft, aircraft engines, and aircraft systems. Personnel are specially trained in ABDR to support a single weapon system, but can provide limited assistance on other aircraft. The ability for teams to accomplish maintenance is limited by the availability of special tools and support equipment. ABDR teams consist of technicians, assessors, and engineers. These three disciplines comprise a highly trained, elite maintenance force (Holcomb, 1994:17). Each discipline is defined as follows:

<u>ABDR Technician</u>- aircraft maintenance personnel trained to repair battle damaged aircraft using techniques learned in the ABDR technician course (Feiler, 1989:13).

<u>ABDR Assessor</u>- aircraft maintenance technician who is trained to evaluate battle damage, estimate repair times, specify the repairs to be made, and estimate constraints on the capability of the aircraft after the repair (McMahon, 1986:5).

<u>ABDR Engineer</u>- provides on-site engineering support to CLSS ABDR teams for all phases of maintenance, modification, aircraft damage assessment and repair. Engineers can authorize deviations to technical order instructions and act as a liaison between the weapon system support manager and the unit (CLSSMP, 2001:11).

Open lines of communication between ABDR teams and the host unit is key to providing aircraft that can be scheduled and employed. Team leadership and the ability to blend into the host operation are vital to the overall function of an ABDR team. The team chief is the principal advisor to the supported commander on ABDR. When an

ABDR team arrives at the deployed location, the team chief presents a briefing to the commander on the capabilities of the ABDR team. As aircraft are damaged and repaired, the establishment of good communication allows the team chief to continually update the commander on aircraft status.

In today's operational environment, the use of ABDR techniques during a conflict, facilitated by the use of ABDR trailers, improves combat readiness. Studies such as the one conducted by LMI have shown that sortie rates can be increased by more than 30% in the tenth day of a conflict with the application of an aggressive ABDR function. CLSS units constantly train their personnel on state of the art technology in the field of battle damage repair (ABDREH, 1996:6). Today's ABDR function enhances the war fighting capability and maintains a powerful fighting force throughout a conflict. The combined efforts of all participants on an ABDR team guarantee that in future conflicts, damaged aircraft will be repaired and returned to operational status in minimum time.

Investigative Question Three

How does the current method of prepositioning ABDR trailers in strategic locations throughout the world meet time requirements in potential wartime situations?

Because of the need for a rapid response in a wartime situation, the AF needs to react quickly at the onset of hostilities. Although there are times when potential conflicts may allow some lead-time, many conflicts happen with little or no warning. To combat this, the AF prepositions military equipment and supplies near potential areas of conflict to ensure its availability to forces in the event of a crisis. The prepositioning of

equipment speeds response times because only troops and a relatively small amount of material need to be transported by airlift into the conflict area (GAO, 1998:2).

To support ABDR resource needs, the AF utilizes prepositioning to respond with the rapid placement of ABDR trailers. Trailers are stored at various locations throughout the world to support PACOM, EUCOM, and CENTCOM contingencies. These locations are listed in chapter two. Location decisions were made by HQ USAF based on recommendations from AFMC with inputs from PACOM, EUCOM, and CENTCOM to support the major Operational Plans (OPLAN) for these theaters (Nyberg, 2003). OPLANs are prepared by combatant commanders in response to requirements established by the Chairman of the Joint Chiefs of Staff and by commanders of subordinate commands in response to requirements tasked by the establishing unified commander. An OPLAN is an operation plan for the conduct of joint operations that can be used as a basis for development of an operation order. It identifies the forces and supplies required to execute the combatant commander's strategic concept and a movement schedule of these resources to the theater of operations. The forces and supplies are identified in TPFDD files. OPLANs include all phases of the tasked operation (JP 1-02, 2003).

WRM is positioned as either starter or swing stock, or a combination of both, to maximize worldwide warfighting capability. Unified Commands identify their starter stock requirements in their TPFDD or equivalent source document. Starter stocks are those assets required at or near the point of intended use until air and sea lines of communications are capable of sustaining operations. Swing stocks are the total OPLAN requirements minus the starter stock (AFI 25-101, 2000:15). The ABDR trailers that support EUCOM and CENTCOM are considered swing stock and are prepositioned at

the central WRM storage facility at Sanem, Luxembourg, a facility that consists of more than 90 acres of land and 50,000 square feet of warehouses (Miller, 2003:1). These trailers are designated as swing stock in order to maximize flexibility to support multiple theaters. They can be easily airlifted throughout EUCOM or CENTCOM, based on the vast number of channel lift missions, or transported by sea or ground over well-established sea channels and surface transportation routes (Jeffries, 2004). The ABDR trailers that are projected for use within PACOM are located at the bases of intended use since the operation locations are known in advance (Nyberg, 2003). These trailers would merely be released from WRM at the outbreak of war and do not require transportation of any kind. Since the PACOM trailers are already prepositioned at the operating location, the remainder of this section focuses on the prepositioned ABDR trailers at Sanem, Luxembourg.

The movement of ABDR trailers is dictated through the TPFDD process just like an ABDR team UTC. The supported command, in this case both EUCOM and CENTCOM, enters the requirement in the applicable OPLAN TPFDD for both the ABDR team and trailer at a specific location. The supported command determines the earliest arrival date (EAD), latest arrival date (LAD), and required delivery date (RDD) based on when the capability (UTC) is required. During the deliberate planning process, these dates are filled in so transportation requirements can be calculated to ensure the plan is executable. At execution, these dates may be adjusted based on changes to aircraft beddown locations, additions/deletions, or how the contingency is unfolding (Nyberg, 2003). However, from a deliberate planning perspective and as typically seen at execution, ABDR teams and their equipment are required before the onset of hostilities.

Therefore, the EAD, LAD, and RDD in the TPFDD are listed in C-Days. A C-Day is an unnamed day that a deployment operation commences or is to commence. ABDR team dates are typically C000 to C020. At execution, some dates may change to N-Days, which signify a negative C-Day, or the number of days preceding C-Day (Nyberg, 2004).

Based on the dates entered in the TPFDD, HQ AFMC coordinates with the WRM monitor for the ABDR trailers to begin movement (Jeffries, 2004). The WRM monitor is the 86th Material Maintenance Squadron (MMS) located at Sembach Air Base, Germany. The squadron manages and maintains the centrally stored non-munitions WRM for United States Air Forces in Europe. More specifically, the ABDR trailers are monitored by the 86th Aerospace Ground Equipment (AGE) Flight. HQ AFMC validates the tasking for the trailers and notifies the WRM monitor to pull the required trailers from storage and prepare them for transportation. USTRANSCOM determines the mode of transportation depending on the destination and on the dates entered in the TPFDD. The appropriate transportation is arranged so the trailers arrive when required. Depending on the location and priority, trailers may be transported by air, land, or sea. HQ AFMC validates the transportation requirements to make sure the trailers arrive with the ABDR team (Nyberg, 2004).

To determine if the prepositioning of ABDR trailers meets time requirements, it would be necessary to assume that the delivery time of ABDR trailers is constant. However, for this situation an assumption is not practical because of the uncertainties involved in carrying out the delivery. As discussed earlier, time requirements may change and TPFDD inputs tailored as a contingency unfolds. Therefore, the delivery times can generally be considered as random variables that have associated probability

distributions. A Beta distribution is commonly used to demonstrate the duration of uncertain activities. Three critical time estimates are used to approximate the Beta distribution as explained by Fitzsimmons and Fitzsimmons (2004:401). They are as follows:

1. *Optimistic time (A)*- this is the duration of an activity if no complications or problems occur. As a rule of thumb, there should be about a one percent chance of the actual duration being less than A.

2. *Most likely time (M)*- this is the duration that is most likely to occur. In statistical terms, M is the modal value.

3. *Pessimistic time (B)*- this is the duration of an activity if extraordinary problems arise. As a rule of thumb, there should be about a one percent chance of the actual duration ever exceeding B.

These three time estimates are used to calculate the mean and variance of each distribution. The formula for the mean is a weighted average. The modal value is given a weight of four. The standard deviation formula assumes time A and time B are six standard deviations apart. This is based on the stipulation that the 98% of the distribution should be contained within the range $A - B$. The activity variance formula will be used to calculate the delivery completion time distribution (Fitzsimmons and Fitzsimmons, 2004:402). The formulas used are:

$$\text{Mean } (t) = (A + 4M + B)/6 \tag{1}$$

$$\text{Standard Deviation } (\sigma) = (B - A)/6 \tag{2}$$

$$\text{Variance } (\sigma^2) = (B - A)^2/36 \tag{3}$$

Due to lack of actual data, subject-matter experts from the ABDR PO were asked to provide an optimistic, pessimistic, and most likely time for the delivery of ABDR trailers. This provided the parameters for the Beta distribution used in the calculation of the probabilities. To obtain the estimated times, a scenario was presented to the subject-matter experts. The scenario encompasses the delivery of five ABDR trailers (ABDR PO recommendation) from the storage facility at Luxembourg to Al Udeid Air Base, Qatar. The number of trailers to be deployed matches the number of ABDR teams to be deployed. The distributions for the delivery times are shown in Table 8.

Table 8. Prepositioned Delivery Time

ABDR Trailer Delivery Time Using Prepositioning					
	Time Estimates (days)				
Expert	A	M	B	Variance	Expected Duration
1	2	4	11	2.25	5
2	3	5	10	1.36	6
3	2	4	10	1.78	5
4	3	5	11	1.78	6
5	2	4	10	1.78	5
Average	2	4	10	1.79	5

This table shows that the expected delivery time for the five ABDR trailers is five days. A 99% confidence interval about these estimates was calculated and resulted in an upper bound of 6.73 (approximately six days, eighteen hours) and a lower bound of 4.47 (approximately four days, twelve hours). The researcher is 99% confident that the true mean of trailer delivery time via prepositioning will fall within this interval. Table 8 will be compared with the airlift results later in this chapter.

Investigative Question Four

What support does airlift, assuming trailers are not prepositioned, provide for ABDR capability in a wartime environment?

Airlift provides rapid and flexible mobility options that allow military forces to respond to and operate in a wider variety of circumstances. It provides military forces the global reach capability to quickly apply strategic global power to various situations throughout the world by delivering essential forces (AFDD 1, 2003:61). Strategic airlift forces provide airlift into theaters from outside the theater while theater airlift provides airlift between terminals within a theater (JP 3-17, 1995:I-1).

USTRANSCOM is the primary provider for the movement of personnel and equipment. It provides the scheduling of transportation needs from the Ports of Embarkation to the Ports of Debarkation in theater (Kee, 1996:14). USTRANSCOM executes its mission through three component commands as well as the component command's respective reserve, National Guard, and commercial counterparts. AMC is the air component of USTRANSCOM and is responsible for the management of airlift assets within and between theaters. AMC provides airlift, aerial refueling, and medical evacuation transportation services and aerial-port management services. AMC is also the single point of contact with the commercial airline industry for procurement of defense airlift services and mobilizing the CRAF (Hazdra, 2000:9).

AMC standardizes global air mobility processes and functions and is present around the world with fixed operating sites, deployable support teams, liaison teams, and air mobility forces continuously operating. AMC controls several air mobility components to execute its mobility missions that, in turn, encompass a multitude of airlift

programs. Airlift operations include cargo airlift through conventional or combat delivery means, passenger airlift, to include aeromedical evacuation, and special operations (AMMP2004, 2003:37).

Cargo airlift is the airlift of supplies and equipment that cannot wait on surface transportation due to urgency. One category of cargo airlift is rolling stock, which is equipment such as ABDR trailers that can be driven or rolled into the aircraft cargo section (AMMP2004, 2003:38). Two of the more common airlift programs used by AMC to meet the demand for airlift are channel missions and special assignment airlift missions (SAAM). Channel missions provide general airlift service over an extended period of time and usually on fixed route structures and schedules. SAAMs provide airlift for more specific requirements at times and places requested by a specific user (JP 3-17, 1995:I-6).

If resources are required to be transported by air, USTRANSCOM relays requirements to the AMC Tanker Airlift Control Center (TACC) (AMSP2002, 2002:59). TACC handles a complex system of programs and assets by tasking units to schedule, task, manage, coordinate, control, and execute AMC missions and requirements. The TACC provides centralized control of Air Mobility assets as the single point of contact for the worldwide air mobility missions (Hazdra, 2000:12). The Tanker Airlift Control Element (TALCE) is a mobile command and control unit that is deployed to support theater air mobility operations. TALCEs are attached to the command of a combatant commander as a part of TACC. Strategic and theater mobility support requirements dictate the position of TALCE assets and it is a theater responsibility to identify such requirements. A Mission Support Team (MST) is smaller than a TALCE and performs

similar functions at locations where airlift command and control does not exist (JP 3-17, 1995:II-3).

For the movement of ABDR trailers from CONUS to a deployed location, the combatant commander validates the required movement based on the TPFDD. The TPFDD is USTRANSCOM's validated airlift request, which USTRANSCOM uses to mobilize and task its subordinate staffs and forces (Kee, 1996:37). USTRANSCOM decides how the movement will be accomplished, whether by surface, sea, or air, or a combination of any two or three. If airlift is the chosen method, then USTRANSCOM will forward the airlift requirement to the TACC within AMC. The TACC will then determine what method (C-17, commercial, etc.) to use to accomplish the airlift. At this point personnel within the TACC will communicate with personnel at the onload location to discuss specific requirements for the movement. TACC will then allocate aircraft for the movement of the ABDR trailers by tasking a specific airlift wing(s) directly. The TACC also tasks a TALCE or MST to travel to the onload location to control the movement of the trailers. TALCE or MST personnel will accomplish final discussions with the onload personnel to determine the finalized process for the movement. This is necessary because many times changes can occur up to the time of the actual load (Johnson, 2004).

More specific analysis of this question is accomplished in the same manner as analysis of investigative question three. To determine if the airlift of ABDR trailers would meet time requirements, it again would be necessary to assume that the delivery time of ABDR trailers is constant. However, for this situation an assumption is not practical because of the uncertainties involved in carrying out the delivery. As discussed

earlier, due to lack of actual data, subject-matter experts from the ABDR PO were asked to provide an optimistic, pessimistic, and most likely time for the airlift delivery of ABDR trailers. To obtain the estimated times, a complementary scenario was presented to the subject-matter experts. The scenario encompasses the delivery of five ABDR trailers via the C-17 aircraft from Hill AFB to Al Udeid Air Base, Qatar. The distributions for the delivery times are shown in Table 9.

Table 9. Airlift Delivery Time

ABDR Trailer Delivery Time Using Airlift					
	Time Estimates (days)				
Expert	A	M	B	Variance	Expected Duration
1	4	7	14	2.78	8
2	5	8	15	2.78	9
3	4	7	14	2.78	8
4	5	8	15	2.78	9
5	4	7	13	2.25	8
Average	4	7	14	2.67	8

This table shows that the expected delivery time for the five ABDR trailers is eight days. Again, it was necessary to find a 99% confidence interval about these estimates. An interval was calculated and resulted in an upper bound of 9.53 (approximately nine days, twelve hours) and a lower bound of 7.27 (approximately seven days, seven hours). The researcher is 99% confident that the true mean of trailer delivery time via airlift will fall within this interval.

Delivery Time Comparison

Earlier analysis illustrated the estimated delivery times in two scenarios, one using prepositioning and the other using airlift, and resulted in the establishment of an

estimated mean for both. To assess the reliability of the estimated means, confidence intervals were found for the means. Table 10 summarizes the calculated confidence intervals.

Table 10. Confidence Interval Comparison

Method	*Coefficient*	*Degrees of freedom*	*Lower Bound*	*Upper Bound*
Prepositioning	0.99	4	4.47	6.73
Airlift	0.99	4	7.27	9.53

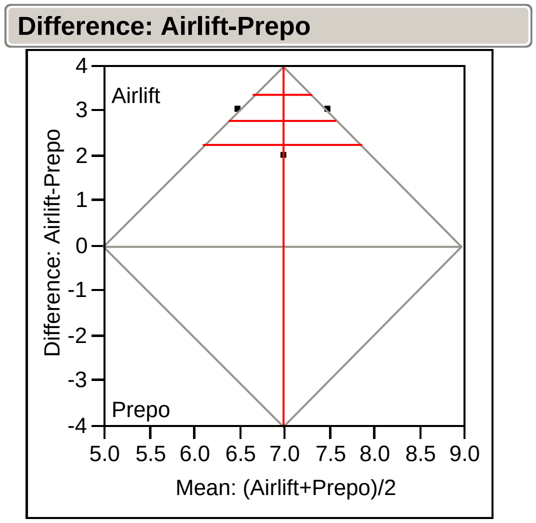
A simple comparison of the two estimated delivery time means, as seen in Table 8 and Table 9, demonstrates that the delivery times are not equal. Additional evidence is provided through comparing the two confidence intervals. Table 10 highlights the difference between the upper bound of the prepositioning interval and the lower bound of the airlift interval. It is easy to see that the two intervals do not overlap.

To test for statistical significance, it was necessary to compare the means. A Paired Difference Test of Hypothesis was used to show a statistical difference in the means between the different methods of trailer delivery. The hypotheses for the comparison are:

- H_o: The difference of the means for the population is equal to zero.

- H_a: The difference of the means for the population is greater than zero.

SAS JMP 5.1 statistical software was used to conduct the hypothesis-testing procedures and form the confidence interval for the difference between the two means. The results are shown in Figure 12.



Airlift	8.4	t-Ratio	14
Prepo	5.6	DF	4
Mean Difference	2.8	Prob > |t|	0.0002
Std Error	0.2	Prob > t	<.0001
Upper95%	3.35529	Prob < t	0.9999
Lower95%	2.24471		
N	5		
Correlation	0.66667		

Figure 12. Analysis of Difference of Means

Figure 12 shows a mean difference for the two methods of 2.8 and a 95% confidence interval with an upper bound of 3.36 and a lower bound of 2.24. Thus, it can be concluded with 95% accuracy that the prepositioning method can save between 3.36 days and 2.24 days of delivery time over the airlift method for demand at Al Udeid. Additional evidence is provided through the calculation of a *t* statistic. As seen in Figure 12, with a coefficient of .95, the probability that the *t* statistic is less than the critical value is less than .0001. Therefore, H_o is rejected in favor H_a and it can be concluded that the means are statistically different.

Further analysis was conducted by determining the probability of delivering ABDR trailers within a specified time. The variances and expected durations were

calculated by using equations (1) and (3) and are given in Table 8 and Table 9. It is expected that the delivery time of ABDR trailers would be five days using prepositioning and eight days using airlift. To determine the probability of delivering the trailers within a specified number of days (*X*), the *Z* value for the standard normal deviate is calculated using the following equation (Fitzsimmons and Fitzsimons, 2004:403):

$$Z = \frac{X - \mu}{\sigma} \qquad (4)$$

Based on the calculations of the *Z* value and use of the standard normal table, Table 11 provides the probabilities associated with the specified time in relation to the proposed method of delivery.

Table 11. Average Delivery Time Probabilities

Method	X	μ	σ	Z Value	Probability
Prepositioning	4	5	1.33	-0.7975	21%
Airlift	4	8	1.63	-2.4673	1%
Prepositioning	6	5	1.33	0.6978	76%
Airlift	6	8	1.63	-1.2439	11%
Prepositioning	8	5	1.33	2.1932	99%
Airlift	8	8	1.63	-0.0204	49%

The probabilities listed in Table 11 can be interpreted as a measure of the degree of belief in the time it will take to deliver the ABDR trailers. The table shows that the probability of delivering trailers within a specified time is higher if the method chosen is prepositioning.

Summary

This chapter addressed each of the investigative questions based on the analysis performed in this study. Data collected was used as a baseline to determine historical and current methods for accomplishing ABDR. An analysis of delivery methods was conducted to include a time comparison based on inputs from subject-matter experts. In chapter five, the conclusions and recommendations will be presented based on the analysis and findings in this chapter.

V. Conclusions and Recommendations

Overview

The purpose of this study was to determine if the AF should continue to preposition ABDR trailers in preparation for combat operations as an alternative to airlift. In Chapter one, a brief introduction of the issues and the primary research question were presented. Chapter two provided a background of ABDR, prepositioning, and airlift, and chapter three identified a methodology to collect and analyze data. The results of the data analysis were presented in chapter four. This chapter will briefly summarize the results followed by the conclusions drawn from the data. The chapter will end with a discussion of limitations and recommendations for further research.

Conclusions

Investigative Questions One and Two

The first and second investigative questions focus on the area of ABDR, beginning with its early uses and ending with current methods in today's operational environment. This research provides the answers to these questions, resulting in a thorough understanding of the circumstances and events leading to the creation of the ABDR Program. The USAF has developed a highly effective ABDR Program based on its own historical experience, lessons learned from its allies, and numerous studies illustrating the effectiveness of ABDR. Studies cited in this research have shown that an effective ABDR Program is a force multiplier.

Through analysis of the literature, it has been determined that there is a high chance that the number of damaged or destroyed aircraft will be great enough to

influence the outcome of a combat operation. The possibility exists that a significant number of aircraft will return from combat missions with some type of damage that will prevent their use in further missions unless repaired. ABDR provides the capability to rapidly restore sufficient strength and serviceability to permit damaged aircraft the opportunity to fly additional missions. During the initial phase of hostilities, an ABDR capability is vital to the objective of gaining air superiority. This capability increases if an ABDR team has the required specialized tools and equipment necessary for battle damage repair. The potential for aircraft damage makes it imperative that an ABDR team has ABDR trailers upon arrival at a deployed location. By answering investigative questions one and two, the researcher has determined that ABDR trailers are needed at the onset of hostilities. Based on this conclusion, what is the best method to ensure that ABDR trailers are delivered in a timely manner? Investigative questions three and four address meeting the delivery requirements for ABDR trailers with either prepositioning or airlift.

Investigative Questions Three and Four

This research highlights the capabilities of both prepositioning and airlift in support of potential wartime situations. It has shown that both methods have inherent strengths and weaknesses, depending on requirements. For this study, the requirement is to minimize the time of delivery of ABDR trailers to a deployed location.

Prepositioning has proven to be successful in replacing overseas manpower and forward presence. Studies have shown that prepositioning has been an effective method for combat forces support, especially when used in combination with airlift. However, this combination should most likely be limited to intratheater airlift because airlift

shortfalls are most prevalent for the strategic, intertheater airlift. The AF continues to seek ways to make its airlift component survivable, reliable and efficient. In many cases, the issues facing airlift add constraints to an already tired system. For example, shortfalls in capacity, lack of appropriate funding, and poor spares support diminish the ability to meet the objective of rapidly transporting ABDR trailers anywhere on the globe. These problems with airlift provide legitimate arguments for the continued prepositioning of ABDR trailers.

The prepositioning of ABDR trailers provides relief to strained airlift resources. Trailers currently positioned overseas will reduce the amount of required airlift to deployed locations. Additionally, alternative modes of transport such as ground transportation are available in many situations, depending on location and requirement. In some cases, the need for airlift could be eliminated completely. This is important since it is unlikely that enough airlift will be available to support the delivery of all required cargo from CONUS, especially at the onset of hostilities.

Recommendations

The AF should continue to preposition ABDR trailers to augment strategic airlift during combat operations. Prepositioning of ABDR trailers provides the answer to the increased readiness required to meet delivery objectives and offers a higher probability than airlift of delivering trailers within a specified time. The placement of ABDR trailers at various CLSSs within CONUS would create a dependency on airlift, a method that is too unpredictable to support rapid ABDR trailer delivery. Strategic airlift shortfalls create severe doubts that ABDR trailers would arrive in the time necessary to support combat operations. Table 12 summarizes the results of the calculated probabilities.

Table 12. Average Delivery Time Probability Summary

Method (Std Dev)	*Within 4 Days*	*Within 6 Days*	*Within 8 Days*
Prepositioning (1.33)	21%	76%	99%
Airlift (1.63)	1%	11%	49%

This table illustrates the advantage of using prepositioning versus airlift. On average, prepositioning provides a 45% better chance of delivering ABDR trailers on time. Referring back to Figure 4 in chapter two, the difference shown in Table 12 could prove to be crucial in the outcome of a combat operation. At the end of ten days in a combat operation, a unit with an excellent repair capability is able to produce four times as many aircraft as a unit with no repair capability. A deployed CLSS ABDR team provides this excellent repair capability when armed with the right tools and equipment. Thus, an excellent repair capability is greatly increased with the presence of ABDR trailers at the beginning of a conflict. The prepositioning method is more effective and timely than the airlift method for delivering ABDR trailers during a combat operation. It greatly increases the flexibility of CLSS ABDR teams and allows them to deploy with a minimal logistics footprint. The results of this research support the proposal of augmenting strategic airlift with the prepositioning of ABDR trailers.

Limitations

This research is limited by the accuracy of the data provided by the ABDR PO subject-matter experts and the number of experts. The estimated delivery times provided are the basis for this research. While much data has been collected for this study, actual delivery times were unavailable. Therefore, the results of this study are based on

subjective responses. As a result, this study only provides an estimate of delivery times based on the use of prepositioning and airlift methods.

Further Research

Further research could to be conducted to find more realistic values for the delivery times of ABDR trailers. Actual delivery times could be referenced for different combat operations and compared to the estimates used in this study to further validate the results presented here.

Additionally, specific tasks that comprise the delivery process for both prepositioning and airlift could be explored using critical path analysis to develop simulation model inputs. The delivery process can vary widely in its complexity and resource requirements. The delivery of ABDR trailers has important dimensions that involve planning, scheduling, and controlling the specific tasks necessary to meet delivery time requirements that could be explored in such a simulation study.

Finally, the relevance of cost could be investigated. The focus for this study was on the effectiveness of ABDR trailer delivery, thus cost was not considered, but it remains an important consideration. A cost comparison of prepositioning and airlift could be accomplished to determine the most efficient method of ABDR trailer delivery. It is important to keep in mind that such a study would identify conflicts between effectiveness and efficiency and a method for analyzing tradeoffs between multiple objectives would have to be identified early in the study.

Summary

This study was undertaken to determine if the AF should continue to use prepositioned ABDR trailers to augment strategic airlift during combat operations. The

purpose was to present research findings that will facilitate decisions made about the prepositioning of ABDR trailers. Investigative questions and research propositions were developed to meet the purpose of the study. Data was collected and analyzed through implementation of the methodology.

The results revealed that the ability to rapidly repair combat-damaged aircraft and return them to the fight could prove crucial in future wartime environments. Analysis of combat experiences shows that aircraft availability and sortie rates can be increased significantly through application of ABDR techniques. For a CLSS ABDR team, the proper application of these techniques relies on the use of an ABDR trailer. The most effective method for delivering ABDR trailers for use by an ABDR team is through prepositioning. This method best ensures the delivery of the right resources in the right place at the right time.

Appendix A: ABDR Trailer Master Listing
Materials

PART NO.	NOUN	DESCRIPTION	REQ	UOI	COST	TOTAL
MS21900-10	Nipple Boss	Flared/Flareless	**10**	EA	$ 5.11	$ 51.10
MS21900-8	Nipple Boss	Flared/Flareless	**10**	EA	$ 4.74	$ 47.40
MS21900-6	Nipple Boss	Flared/Flareless	**20**	EA	$ 10.95	$ 219.00
MS21900-4	Nipple Boss	Flared/Flareless	**20**	EA	$ 3.61	$ 72.20
MS21900-3	Nipple Boss	Flared/Flareless	**4**	EA	$ 6.42	$ 25.68
MS21900-16	Nipple Boss	Flared/Flareless	**4**	EA	$ 14.03	$ 56.12
MS21900-12	Nipple Boss	Flared/Flareless	**10**	EA	$ 5.01	$ 50.10
MS21900-5	Nipple Boss	Flared/Flareless	**10**	EA	$ 4.84	$ 48.40
AN984D8-6	Nipple Boss	Straight, Tube to Boss	**6**	EA	$ 4.62	$ 27.72
NAS1303-8	Bolt	shear	**300**	EA	$ 0.08	$ 24.00
NAS1304-6	Bolt		**3**	HD	$ 10.56	$ 31.68
NAS1304-4H	Bolt		**300**	EA	$ 0.54	$ 162.00
NAS1303-6	Bolt		**300**	EA	$ 0.39	$ 117.00
NAS1304-10H	Bolt		**300**	EA	$ 0.93	$ 279.00
NAS1303-10	Bolt		**300**	EA	$ 0.36	$ 108.00
NAS1303-4	Bolt		**3**	HD	$ 5.84	$ 17.52
NAS1305-8	Bolt		**300**	EA	$ 0.29	$ 87.00
NAS1305-4	Bolt		**300**	EA	$ 0.31	$ 93.00
NAS1305-10	Bolt		**300**	EA	$ 0.42	$ 126.00
NAS1305-6	Bolt		**300**	EA	$ 0.43	$ 129.00
NAS1304-8	Bolt		**30**	PG	$ 0.13	$ 3.90
NAS1801-4-20	Bolt	1/4-28UNJF	**100**	EA	$ 0.46	$ 46.00
MS20073-03-14	Bolt Machine	#10 x 1.5"	**1**	HD	$ 51.60	$ 51.60
MIL-W-83420,	Cable Rope wire	5/32" 7 X 19	**0.2**	RO	$332.16	$ 66.43
R44117T-04	Cap Tube	Lipseal Fitting	**20**	EA	$ 33.72	$ 674.40
R44117T-06	Cap Filler opening	Lipseal Fitting	**20**	EA	$ 27.82	$ 556.40
R44117T-12	Cap Pressure	Lipseal Fitting	**20**	EA	$ 0.99	$ 19.80
R44117T-16	Cap Tube	Lipseal Fitting	**4**	EA	$ 75.45	$ 301.80
R44117T-10	Cap Tube	Lipseal Fitting	**20**	EA	$ 36.16	$ 723.20
R44117T-08	Cap Tube	Lipseal Fitting	**20**	EA	$ 32.05	$ 641.00
R44117T-21	Cap Pressure	Lipseal Fitting	**4**	EA	$119.59	$ 478.36
MS25274-3	Cap, Electrical	14/16 AWG, Blue	**4**	PG	$ 1.65	$ 6.60
AN929-3	Cap Tube	Flared	**8**	EA	$ 0.50	$ 4.00
AN929A12J	Cap Tube	Flared	**8**	EA	$ 6.12	$ 48.96
AN929-8S	Cap Tube	Flared	**20**	EA	$ 3.83	$ 76.60
AN929A6	Cap Tube	Flared	**20**	EA	$ 0.89	$ 17.80
AN929A4	Cap Tube	Flared	**20**	EA	$ 0.68	$ 13.60
AN929A20	Cap Tube	Flared	**4**	EA	$ 15.55	$ 62.20
AN929A5	Cap Tube	Flared	**8**	EA	$ 0.64	$ 5.12
AN929A24	Cap Tube	Flared	**4**	EA	$ 11.52	$ 46.08
AN929A16	Cap Tube	Flared	**6**	EA	$ 3.62	$ 21.72
AN929-10J	Cap Tube	Flared	**8**	EA	$ 4.19	$ 33.52
MS21914-16	Cap Tube	Flareless	**6**	EA	$ 7.23	$ 43.38
MS21914-3	Cap Tube	Flareless	**8**	EA	$ 2.14	$ 17.12
MS21914-8	Cap Tube	Flareless	**20**	EA	$ 4.19	$ 83.80

PART NO.	NOUN	DESCRIPTION	REQ	UOI	COST	TOTAL
MS21914-20	Cap Tube	Flareless	**4**	EA	$ 17.32	$ 69.28
MS21914-6	Cap Tube	Flareless	**20**	EA	$ 2.70	$ 54.00
MS21914-10	Cap Tube	Flareless	**8**	EA	$ 8.13	$ 65.04
MS21914-5	Cap Tube	Flareless	**8**	EA	$ 2.23	$ 17.84
MS21914-4	Cap Tube	Flareless	**20**	EA	$ 2.17	$ 43.40
MS21914-12C	Cap Tube	Flareless	**6**	EA	$ 8.46	$ 50.76
MS35842-15	Clamp		**20**	EA	$ 0.75	$ 15.00
AN737TW56-66	Clamp, Hose		**20**	EA	$ 1.35	$ 27.00
AN737TW74-91	Clamp, Hose,		**20**	EA	$ 0.77	$ 15.40
MS35842-14	Clamp, Hose,		**20**	EA	$ 0.42	$ 8.40
AN737TW22	Clamp, Hose,		**20**	EA	$ 1.08	$ 21.60
AN737TW34-38	Clamp, Hose,		**20**	EA	$ 0.99	$ 19.80
AN737TW24-30	Clamp, Hose,		**20**	EA	$ 0.94	$ 18.80
MS16842-2	Clamp Wire Rope	U Bolt	**40**	EA	$ 0.75	$ 30.00
STJ9M623-125	Clamp, Worm Band		**20**	EA	$ 1.14	$ 22.80
MS21256-2	Clip, Retaining,	Turnbuckle	**50**	EA	$ 0.14	$ 7.00
MS21256-3	Clip, Retaining,	Turnbuckle	**50**	EA	$ 0.27	$ 13.50
MS21256-1	Clip, Retaining,	Turnbuckle	**50**	EA	$ 0.13	$ 6.50
R44150P-16	Connector	Dynatube	**6**	EA	$ 78.07	$ 468.42
R44150P-12	Connector (Coupling Boss)	Dynatube	**8**	EA	$ 54.70	$ 437.60
FF-P-386	Cotter Pins	(Assorted Sizes)	**2**	AT	$ 1.21	$ 2.42
MIL-C-4110	Coupling Half, Female	QD, Air Hose	**2**	EA	$ 4.52	$ 9.04
MIL-C-4109	Coupling Half, Male	QD, Air Hose	**2**	EA	$ 4.40	$ 8.80
ST2000-08	Adapter Stright	Tube to Boss	**6**	EA	$ 29.82	$ 178.92
ST2000-10	Adapter Stright	Tube to Boss	**4**	EA	$ 35.00	$ 140.00
ST2000-06	Adapter Stright	Tube to Boss	**4**	EA	$ 7.87	$ 31.48
ST7M393P4	Coupling, Boss	(Dynatube)	**4**	EA	$ 7.87	$ 31.48
ST27M241P4	Nipple Tube	(Dynatube)	**6**	EA	$ 20.33	$ 121.98
ST7M393P6	Fitting Connector	(Dynatube)	**4**	EA	$ 54.36	$ 217.44
ST7M393P10	Coupling, Boss	(Dynatube)	**6**	EA	$ 57.46	$ 344.76
STM393P8	Coupling, Boss	(Dynatube)	**6**	EA	$ 56.84	$ 341.04
AN827-6D	Cross, Tube		**4**	EA	$ 8.52	$ 34.08
AN839-12D	Elbow, 45 Deg.	Flared	**4**	EA	$ 23.86	$ 95.44
AN839-16D	Elbow, 45 Deg.	Flared	**4**	EA	$ 22.51	$ 90.04
29712-6-6CR	Elbow, 45 Deg.	Flareless	**4**	EA	$ 32.82	$ 131.28
MS28780-10	Elbow, 45 Deg.	Flared	**4**	EA	$ 75.58	$ 302.32
MS28780-8	Elbow, 45 Deg.	Flared	**4**	EA	$ 22.52	$ 90.08
MS28780-6	Elbow, 45 Deg.	Flared	**4**	EA	$ 10.99	$ 43.96
MS28780-4	Elbow, 45 Deg.	Flared	**4**	EA	$ 17.81	$ 71.24
AN838-12D	Elbow, 90 Deg.	Flared	**6**	EA	$ 32.59	$ 195.54
AN838-16D	Elbow, 90 Deg.	Flared	**4**	EA	$ 31.26	$ 125.04
MS28781-6	Elbow, 90 Deg.	Flared	**4**	EA	$ 67.31	$ 269.24
MS28781-4	Elbow, 90 Deg.	Flared	**4**	EA	$ 13.53	$ 54.12
MS28781-10	Elbow, 90 Deg.	Flared	**4**	EA	$ 53.34	$ 213.36
MS28781-8	Elbow, 90 Deg.	Flared	**4**	EA	$ 65.20	$ 260.80

PART NO.	NOUN	DESCRIPTION	REQ	UOI	COST	TOTAL
AN833-6D	Elbow, Tube 90 Deg	Flared	**6**	EA	$ 2.35	$ 14.10
AN821-6J	Elbow, Tube 90 Deg	Flared	**15**	EA	$ 6.65	$ 99.75
AN821-4J	Elbow, Tube 90 Deg	Flared	**15**	EA	$ 5.15	$ 77.25
QQ-A-200/3	Extrusion, L Angle	2024-T3, .063, 7/8X7/8	**24**	FT	$ 2.12	$ 50.88
QQ-A-200/11	Extrusion, L Angle	7075-T6, .125, 1.5X1.5	**24**	FT	$ 4.00	$ 96.00
QQ-A-200/3	Extrusion, T Angle	2024-T3, .063, 1X2	**24**	FT	$ 2.84	$ 68.16
QQ-A-200/11	Extrusion, T Angle	7075-T6, .125, 2X4	**12**	FT	$ 11.15	$ 133.80
QQ-A-200/11	Extrusion, L Angle	7075-T6, .040, 1X1	**24**	FT	$ 4.57	$ 109.68
MS28760-4	Adapter Straight	Tube to Hose	**20**	EA	$ 11.57	$ 231.40
MS28760-8	Adapter Straight	Tube to Hose	**20**	EA	$ 10.28	$ 205.60
MS28760-16	Adapter Straight	Tube to Hose	**4**	EA	$ 19.64	$ 78.56
MS28760-5	Adapter Straight	Tube to Hose	**8**	EA	$ 6.18	$ 49.44
MS28760-6	Adapter Straight	Tube to Hose	**20**	EA	$ 10.64	$ 212.80
MS28760-10	Adapter Straight	Tube to Hose	**4**	EA	$ 12.03	$ 48.12
MS28760-12	Adapter Straight	Tube to Hose	**4**	EA	$ 11.03	$ 44.12
MS28761-16	Adapter Straight	Tube to Hose	**4**	EA	$ 31.61	$ 126.44
MS28761-8	Adapter Straight	Tube to Hose	**20**	EA	$ 9.51	$ 190.20
MS28761-6	Adapter Straight	Tube to Hose	**20**	EA	$ 20.30	$ 406.00
MS28761-12	Adapter Straight	Tube to Hose	**4**	EA	$ 15.80	$ 63.20
MS28761-4	Adapter Straight	Tube to Hose	**20**	EA	$ 5.79	$ 115.80
MS28761-10	Adapter Straight	Tube to Hose	**4**	EA	$ 12.77	$ 51.08
MS28761-5	Adapter Straight	Tube to Hose	**8**	EA	$ 6.60	$ 52.80
AN841-12D	Adapter Straight	Tube to Hose	**4**	EA	$ 12.61	$ 50.44
MIL-H-6000	Hose Nonmetallic	Rubber, 1/4"	**10**	FT	$ 1.86	$ 18.60
NAS1669-4L14	Rivet Blind	Jo-Bolt	**50**	EA	$ 1.00	$ 50.00
NAS1669-4L18	Rivet Blind	Jo-Bolt	**50**	EA	$ 8.50	$ 425.00
NAS1669-4L8	Rivet Blind	Jo-Bolt	**150**	EA	$ 1.28	$ 192.00
NAS1669-3L8	Rivet Blind	Jo-Bolt	**200**	EA	$ 1.39	$ 278.00
NAS1669-4L4	Rivet Blind	Jo-Bolt	**300**	EA	$ 1.16	$ 348.00
NAS1669-4L12	Rivet Blind	Jo-Bolt	**50**	EA	$ 1.54	$ 77.00
NAS1669-5L8	Rivet Blind	Jo-Bolt	**100**	EA	$ 0.98	$ 98.00
NAS1669-3L10	Rivet Blind	Jo-Bolt	**50**	EA	$ 2.17	$ 108.50
NAS1669-3L2	Rivet Blind	Jo-Bolt	**200**	EA	$ 0.99	$ 198.00
NAS1669-3L4	Rivet Blind	Jo-Bolt	**400**	EA	$ 1.64	$ 656.00
NAS1669-3L6	Rivet Blind	Jo-Bolt	**400**	EA	$ 0.96	$ 384.00
NAS1669-4L6	Rivet Blind	Jo-Bolt	**300**	EA	$ 1.44	$ 432.00
NAS1669-3L12	Rivet Blind	Jo-Bolt	**50**	EA	$ 2.07	$ 103.50
NAS1669-4L10	Rivet Blind	Jo-Bolt	**100**	EA	$ 2.79	$ 279.00
NAS1669-5L6	Rivet Blind	Jo-Bolt	**100**	EA	$ 2.05	$ 205.00
NAS1669-5L10	Rivet Blind	Jo-Bolt	**100**	EA	$ 5.32	$ 532.00
NAS1669-4L2	Rivet Blind	Jo-Bolt	**200**	EA	$ 2.67	$ 534.00
NAS1669-4L16	Rivet Blind	Jo-Bolt	**50**	EA	$ 8.96	$ 448.00
QQ-A-250/5	Metal, Alum	2024-0, .040	**1**	SH	$ 72.28	$ 72.28
QQ-A-250/5	Metal, Alum	2024-T3, .032	**1**	SH	$ 52.91	$ 52.91
QQ-A-250/5	Metal, Alum	2024-T3, .040	**1**	SH	$118.26	$ 118.26
QQ-A-250/5	Metal, Alum	2024-T3, .050	**1**	SH	$134.79	$ 134.79

PART NO.	NOUN	DESCRIPTION	REQ	UOI	COST	TOTAL
QQ-A-250/13	Metal, Alum	7075-T6, .063	1	SH	$158.71	$ 158.71
QQ-A-250/13	Metal, Alum	7075-T6, .090	1	SH	$199.28	$ 199.28
QQ-A-250/13	Metal, Alum	7075-T6, .125	1	SH	$349.80	$ 349.80
MIL-S-5059	Metal, St. Steel	1/4 Hard, .040	1	SH	$206.90	$ 206.90
MIL-S-5059	Metal, St. Steel	Annealed, .016	0.5	SH	$ 58.23	$ 29.12
AN815-5D	Nipple Tube		5	EA	$ 2.22	$ 11.10
AN815-6	Nipple Boss		15	EA	$ 2.44	$ 36.60
AN815-8	Nipple Boss		15	EA	$ 2.83	$ 42.45
AN815-10	Nipple Boss		15	EA	$ 4.76	$ 71.40
AN815-12	Nipple Boss		15	EA	$ 4.47	$ 67.05
AN815-16	Nipple Boss		6	EA	$ 8.02	$ 48.12
AN815-4	Nipple Boss		15	EA	$ 1.58	$ 23.70
AN815-20	Nipple Boss		6	EA	$ 24.50	$ 147.00
AN815-4S	Nipple Boss		8	EA	$ 2.90	$ 23.20
AN818-12	Nut Tube Coupling		8	EA	$ 1.87	$ 14.96
AN818-16	Nut Tube Coupling		6	EA	$ 3.21	$ 19.26
AN818L4J	Nut Tube Coupling		16	EA	$ 1.26	$ 20.16
AN818-3J	Nut Tube Coupling		6	EA	$ 0.40	$ 2.40
AN818-8	Nut Tube Coupling		16	EA	$ 0.85	$ 13.60
AN818-20	Nut Tube Coupling		4	EA	$ 5.89	$ 23.56
AN818-6	Nut Tube Coupling		16	EA	$ 0.43	$ 6.88
AN818-4	Nut Tube Coupling		16	EA	$ 0.34	$ 5.44
AN818-5D	Nut Tube Coupling		6	EA	$ 0.38	$ 2.28
AN818-10	Nut Tube Coupling		10	EA	$ 1.49	$ 14.90
MS21921-5J	Nut Tube Coupling		10	EA	$ 3.05	$ 30.50
MS21921-3J	Nut Tube Coupling		10	EA	$ 3.27	$ 32.70
MS21921-12J	Nut Tube Coupling		8	EA	$ 4.29	$ 34.32
MS21921-2J	Nut Tube Coupling		6	EA	$ 8.34	$ 50.04
MS21921-8J	Nut Tube Coupling		50	EA	$ 2.22	$ 111.00
MS21921-10J	Nut Tube Coupling		14	EA	$ 3.32	$ 46.48
MS21921-16J	Nut Tube Coupling		10	EA	$ 8.24	$ 82.40
MS21921-4J	Nut Tube Coupling		50	EA	$ 0.82	$ 41.00
MS21921-6K	Nut Tube Coupling		50	EA	$ 1.75	$ 87.50
NAS67904	Nut Self Locking	1/4" Extended Washer	1000	EA	$ 0.19	$ 190.00
NAS679A3	Nut Self Locking	3/16" Extended Washer	10	HD	$ 7.83	$ 78.30
NAS679C5M	Nut Self Locking	5/16" Hexagon	10	HD	$ 1.39	$ 13.90
PPP-B-20	Parts Bag	White w/string	2	BD	$ 37.15	$ 74.30
MIL-P-15035	Plastic Sheet	1/4"Thick	1	SH	$ 65.28	$ 65.28
LP504	Plastic Sheet	20X50	10	SH	$ 9.92	$ 99.20
AN814-6D	Plug Machine	Thread	10	EA	$ 1.02	$ 10.20
AN814-10D	Plug Machine	Thread	10	EA	$ 1.22	$ 12.20
AN814-4D	Plug Machine	Thread	10	EA	$ 0.83	$ 8.30
AN814-8D	Plug Machine	Thread	10	EA	$ 1.72	$ 17.20
AN814-6	Plug Machine	Thread	10	EA	$ 1.75	$ 17.50
AN814-3D	Plug Machine	Thread	10	EA	$ 0.36	$ 3.60
MS24391-10L	Plug Machine	Thread	10	EA	$ 5.52	$ 55.20
AN814-8	Plug Machine	Thread	10	EA	$ 2.56	$ 25.60

PART NO.	NOUN	DESCRIPTION	REQ	UOI	COST	TOTAL
MS21913-8	Plug Tube Fitting	Threaded	**20**	EA	$ 1.39	$ 27.80
MS21913D12	Plug Tube Fitting	Threaded	**6**	EA	$ 6.60	$ 39.60
MS21913D10	Plug Tube Fitting	Threaded	**8**	EA	$ 1.85	$ 14.80
MS21913-6	Plug Tube Fitting	Threaded	**20**	EA	$ 1.21	$ 24.20
MS21913D16	Plug Tube Fitting	Threaded	**6**	EA	$ 7.45	$ 44.70
AN806D4	Plug Tube Fitting	Threaded	**20**	EA	$ 0.47	$ 9.40
AN806D5	Plug Tube Fitting	Threaded	**8**	EA	$ 0.67	$ 5.36
AN806D6	Plug Tube Fitting	Threaded	**20**	EA	$ 0.64	$ 12.80
AN806D8	Plug Tube Fitting	Threaded	**20**	EA	$ 0.89	$ 17.80
AN806D24	Plug Tube Fitting	Threaded	**4**	EA	$ 0.88	$ 3.52
AN806D10	Plug Tube Fitting	Threaded	**8**	EA	$ 1.28	$ 10.24
AN806D12	Plug Tube Fitting	Threaded	**8**	EA	$ 1.89	$ 15.12
AN806D16	Plug Tube Fitting	Threaded	**6**	EA	$ 2.04	$ 12.24
MS21913-3	Plug Tube Fitting	Threaded	**8**	EA	$ 1.49	$ 11.92
MS21913D20	Plug Tube Fitting	Threaded	**4**	EA	$ 4.09	$ 16.36
MS21913-5	Plug Tube Fitting	Threaded	**8**	EA	$ 1.99	$ 15.92
MS21913-4	Plug Tube Fitting	Threaded	**20**	EA	$ 0.55	$ 11.00
AN806D20	Plug Tube Fitting	Threaded	**4**	EA	$ 2.43	$ 9.72
AN806D3	Plug Machine	Thread	**8**	EA	$ 0.35	$ 2.80
AN919-8	Reducer Boss		**4**	EA	$ 11.94	$ 47.76
AN893-12	Reducer, Boss		**2**	EA	$ 6.48	$ 12.96
NAS1564D6-4	Reducer, Body Tube		**4**	EA	$ 2.67	$ 10.68
CR3243-4-1	Rivet, Blind,	Cherrymax	**2**	HD	$ 44.02	$ 88.04
CR3243-5-5	Rivet, Blind,	Cherrymax	**10**	HD	$ 22.14	$ 221.40
CR3243-6-4	Rivet, Blind,	Cherrymax	**10**	HD	$ 26.41	$ 264.10
CR3243-6-2	Rivet, Blind,	Cherrymax	**4**	HD	$ 45.59	$ 182.36
CR3553-5-3	Rivet, Blind,	Cherrymax	**2**	HD	$136.51	$ 273.02
CR3553-5-5	Rivet, Blind,	Cherrymax	**2**	HD	$120.66	$ 241.32
CR3553-5-8	Rivet, Blind,	Cherrymax	**1**	HD	$338.64	$ 338.64
CR3553-6-4	Rivet, Blind,	Cherrymax	**3**	HD	$ 91.87	$ 275.61
CR3243-5-2	Rivet, Blind,	Cherrymax	**6**	HD	$ 21.26	$ 127.56
CR3243-5-6	Rivet, Blind,	Cherrymax	**5**	HD	$ 22.75	$ 113.75
CR3243-5-4	Rivet, Blind,	Cherrymax	**10**	HD	$ 21.47	$ 214.70
CR3243-6-6	Rivet, Blind,	Cherrymax	**10**	HD	$ 32.71	$ 327.10
CR3243-6-3	Rivet, Blind,	Cherrymax	**10**	HD	$ 25.00	$ 250.00
CR3243-4-3	Rivet, Blind,	Cherrymax	**2**	HD	$ 21.33	$ 42.66
CR3243-4-2	Rivet, Blind,	Cherrymax	**2**	HD	$ 21.87	$ 43.74
CR3243-6-5	Rivet, Blind,	Cherrymax	**10**	HD	$ 21.73	$ 217.30
CR3243-5-3	Rivet, Blind,	Cherrymax	**10**	HD	$ 21.33	$ 213.30
CR3553-6-5	Rivet, Blind,	Cherrymax	**3**	HD	$ 71.16	$ 213.48
CR3553-6-6	Rivet, Blind,	Cherrymax	**3**	HD	$189.92	$ 569.76
CR3553-5-6	Rivet, Blind,	Cherrymax	**2**	HD	$169.26	$ 338.52
CR3553-5-7	Rivet, Blind,	Cherrymax	**1**	HD	$294.23	$ 294.23
CR3553-6-8	Rivet, Blind,	Cherrymax	**1**	HD	$280.06	$ 280.06
CR3553-6-7	Rivet, Blind,	Cherrymax	**1**	HD	$316.72	$ 316.72
CR3553-5-4	Rivet, Blind,	Cherrymax	**5**	HD	$149.31	$ 746.55
CR3553-5-2	Rivet, Blind,	Cherrymax	**2**	HD	$143.27	$ 286.54

PART NO.	NOUN	DESCRIPTION	REQ	UOI	COST	TOTAL
CR3553-6-3	Rivet, Blind,	Cherrymax	**3**	HD	$129.29	$ 387.87
CR3553-6-2	Rivet, Blind,	Cherrymax	**2**	HD	$112.82	$ 225.64
NAS1454C4-1604	Rod, Cont.	Thd,1/4"D,16"L	**3**	EA	$ 4.93	$ 14.79
NAS1454C3-2400	Rod, Cont.	Thd,3/16"D,24"L	**2**	EA	$ 2.51	$ 5.02
65001	Kit Disk Abrasive	Assorted Disc	**1**	KT	$ 41.62	$ 41.62
P-P-101	Sandpaper	120 Grit	**2**	PG	$ 9.07	$ 18.14
MS24617-33	Screw Tapping		**2**	HD	$ 1.09	$ 2.18
MS24617-21	Screw Tapping		**2**	HD	$ 0.97	$ 1.94
NAS1581A3T4	Screw	Close Tolerance	**5**	HD	$ 8.42	$ 42.10
NAS1581A3T3	Screw	Close Tolerance	**5**	HD	$ 8.48	$ 42.40
MS20819-20	Sleeve, Flared	Tube Fitting	**4**	EA	$ 2.41	$ 9.64
MS20819-16	Sleeve, Flared	Tube Fitting	**6**	EA	$ 0.93	$ 5.58
MS20819-10	Sleeve, Flared	Tube Fitting	**10**	EA	$ 0.38	$ 3.80
MS20819-4	Sleeve, Flared	Tube Fitting	**16**	EA	$ 0.12	$ 1.92
MS20819-5	Sleeve, Flared	Tube Fitting	**6**	EA	$ 0.36	$ 2.16
MS20819-8	Sleeve, Flared	Tube Fitting	**16**	EA	$ 0.13	$ 2.08
MS20819-12	Sleeve, Flared	Tube Fitting	**8**	EA	$ 0.77	$ 6.16
MS20819-4J	Sleeve, Flared	Tube Fitting	**10**	EA	$ 0.33	$ 3.30
MS20819-6	Sleeve, Flared	Tube Fitting	**16**	EA	$ 0.21	$ 3.36
MS219922-3	Sleeve, Flareless		**6**	EA	$ 0.46	$ 2.76
MS21922-2C	Sleeve, Flareless		**6**	EA	$ 3.14	$ 18.84
MS21922-10	Sleeve, Flareless		**20**	EA	$ 4.30	$ 86.00
MS21922-8	Sleeve, Flareless		**50**	EA	$ 3.38	$ 169.00
MS21922-6C	Sleeve, Flareless		**50**	EA	$ 1.53	$ 76.50
MS21922-5C	Sleeve, Flareless		**14**	EA	$ 2.06	$ 28.84
MS21922-16C	Sleeve, Flareless		**10**	EA	$ 7.33	$ 73.30
MS21922-4C	Sleeve, Flareless		**50**	EA	$ 0.92	$ 46.00
MS21922-3C	Sleeve, Flareless		**14**	EA	$ 2.26	$ 31.64
MS21922-12C	Sleeve, Flareless		**14**	EA	$ 6.96	$ 97.44
MIL-T-7928/5	Splice Conductor	12/10 AWG, Yellow	**4**	HD	$ 13.69	$ 54.76
MIL-T-7928/5	Splice Conductor	14/16 AWG, Blue	**10**	HD	$ 8.36	$ 83.63
MIL-T-7928/5	Splice Conductor	18/20 AWG, Red	**10**	HD	$ 8.04	$ 80.40
MIL-T-7928/5	Splice Conductor	24/26 AWG, White	**20**	PG	$ 5.57	$ 111.40
MIL-M-20693	Strap, Tie	Elect 6"	**2**	HD	$ 1.45	$ 2.90
MIL-S-23190	Strap, Tie	Elect 13.5"	**2**	HD	$ 2.25	$ 4.50
411143-2	String, Lacing	Waxed	**2**	SL	$ 6.91	$ 13.82
MS51844-25	Swage,Cable (Nico Press)	5/32"Sleeve	**50**	EA	$ 0.15	$ 7.50
MIL-T-23397	Tape, Pressure Sensitive	Alum 3"	**4**	RO	$ 12.99	$ 51.96
58B71311	Tee, Pipe	144083	**2**	EA	$ 3.11	$ 6.22
MS25036-157	Terminal Lug	10/12 AWG,1/4" Hole	**2**	HD	$ 7.21	$ 14.42
MS25036-108	Terminal Lug	14/16 AWG, #10 Hole	**2**	HD	$ 4.12	$ 8.24
MS25036-103	Terminal Lug	18/20 AWG, #10 Hole	**2**	HD	$ 2.85	$ 5.70
MS20659-114	Terminal Lug	2 AWG,3/8" Hole	**40**	EA	$ 0.49	$ 19.60
MS20659-110	Terminal Lug	6 AWG,3/8" Hole	**2**	PG	$ 2.57	$ 5.14
MIL-T-6845	Tube Metallic	5/16 D X .028T wall	**12**	FT	$ 2.41	$ 28.92
MIL-T-6845	Tube Metallic	1" D X.035T wall	**12**	FT	$ 5.52	$ 66.24

PART NO.	NOUN	DESCRIPTION	REQ	UOI	COST	TOTAL
MIL-T-6845	Tube Metallic	1/2 D X.049T wall	**1**	FT	$ 33.57	$ 33.57
MIL-T-6845	Tube Metallic	1/4 D X.035T wall	**12**	FT	$ 1.56	$ 18.72
MIL-T-6845	Tube Metallic	3/16 D X.028T wall	**12**	FT	$ 2.95	$ 35.40
MIL-T-6845	Tube Metallic	3/4 D X.049T wall	**12**	FT	$ 3.99	$ 47.88
MIL-T-6845	Tube Metallic	3/8 D X.035T wall	**12**	FT	$ 1.75	$ 21.00
MIL-T-6845	Tube Metallic	5/8 D X.049T wall	**12**	FT	$ 3.37	$ 40.44
MIL-T-8506	Tube Metallic	1/8"D .035 Wall+D79	**12**	FT	$ 1.93	$ 23.16
MS21924-4	Adapter, Straight	Tube to Boss	**20**	EA	$ 4.12	$ 82.40
MS21924D10	Adapter, Straight	Tube to Boss	**6**	EA	$ 3.79	$ 22.74
MS21924-8	Adapter, Straight	Tube to Boss	**20**	EA	$ 3.20	$ 64.00
MS21924-6	Adapter, Straight	Tube to Boss	**20**	EA	$ 1.66	$ 33.20
MS21924-5C	Adapter, Straight	Tube to Boss	**10**	EA	$ 5.75	$ 57.50
MS21924-12C	Adapter, Straight	Tube to Boss	**4**	EA	$ 10.59	$ 42.36
MS21924-16	Adapter, Straight	Tube to Boss	**4**	EA	$ 6.90	$ 27.60
MS21924-3C	Adapter, Straight	Tube to Boss	**4**	EA	$ 31.24	$ 124.96
AN960D816	Washer Flat		**1**	HD	$ 2.51	$ 2.51
AN960-10L	Washer Flat		**5**	HD	$ 0.54	$ 2.70
AN960-416L	Washer Flat		**500**	EA	$ 0.02	$ 10.00
BACW10UC10	Washer Finishing		**100**	EA	$ 0.02	$ 2.00
BACW10UC416	Washer Finishing		**1**	HD	$ 2.34	$ 2.34
BACW10UC8	Washer Finishing		**1**	HD	$ 1.88	$ 1.88
AN960C416	Washer Flat	Steel,1/4	**20**	HD	$ 1.26	$ 25.20
AN960C10	Washer Flat	Steel,3/16	**20**	HD	$ 1.38	$ 27.60
AN960C516	Washer Flat	Steel,5/16	**10**	HD	$ 1.99	$ 19.90
AN960C8	Washer Flat	Steel,5/32	**10**	HD	$ 0.14	$ 1.40
MIL-W-81044/6	Wire, Elec	10 AWG	**150**	FT	$ 0.60	$ 90.00
MIL-W-81044/6	Wire, Elec	14 AWG	**300**	FT	$ 0.33	$ 99.00
MIL-W-81044/6	Wire, Elec	18 AWG	**300**	FT	$ 0.10	$ 30.00
MIL-C-27500	Wire, Elec	20 AWG, Twisted	**25**	FT	$ 0.68	$ 17.00
MIL-W-81044/12	Wire, Elec	22 AWG	**300**	FT	$ 0.06	$ 18.00
AN995C20	Wire, Safety	.020	**1**	LB	$ 3.57	$ 3.57
AN995F41	Wire, Safety	.041	**1**	LB	$ 3.73	$ 3.73
AN995C32-12	Wire, Safety	'.032	**1**	LB	$ 3.06	$ 3.06
MIL-W-5086	Wire,Elec,4 AWG		**15**	FT	$ 0.91	$ 13.65
B32	Coupling Half	Female,QD	**2**	EA	$ 5.71	$ 11.42
12-3	Coupling Half, Male	QD, 12-3	**2**	EA	$ 0.41	$ 0.82
ZZ-H-461	Hose,Air	25' X 1/4D	**50**	FT	$ 0.24	$ 12.00
ZZ-H-462	Hose,Air	50' X 1/4D	**200**	FT	$ 0.24	$ 48.00
						$31,669.64

Tools

NSN	NOUN	REQ	UOI	COST	TOTAL
5120-00-240-8702	Adapter	2	EA	$ 2.07	$ 4.14
5120-00-227-8095	Adapter	2	EA	$ 1.68	$ 3.36
4730-00-142-5164	Air Chuck	2	EA	$ 21.30	$ 42.60
7930-00-455-9902	Air Lubricator Assy.	1	EA	$ 40.06	$ 40.06
5120-00-935-4641	Allen Wrench Set	1	SE	$ 12.57	$ 12.57
5120-00-223-6971	Bit Screwdriver	10	EA	$ 0.23	$ 2.30
5120-00-595-8197	Bit Screwdriver	40	EA	$ 0.23	$ 9.20
5120-00-250-5576	Bit Screwdriver	20	EA	$ 0.21	$ 4.20
5120-00-226-5606	Bit Screwdriver	10	EA	$ 1.02	$ 10.20
5120-00-888-5831	Bit Screwdriver	10	EA	$ 0.66	$ 6.60
5120-00-888-5827	Bit Screwdriver	10	EA	$ 0.66	$ 6.60
5120-00-888-5826	Bit Screwdriver	10	EA	$ 0.66	$ 6.60
5120-00-797-2992	Screwdriver Attachment Socket Wrench	6	EA	$ 1.92	$ 11.52
5120-00-863-4944	Screwdriver Attachment Socket Wrench	6	EA	$ 4.95	$ 29.70
5120-00-797-2994	Screwdriver Attachment Socket Wrench	6	EA	$ 2.13	$ 12.78
5120-00-863-4942	Screwdriver Attachment Socket Wrench	6	EA	$ 8.17	$ 49.02
5120-00-177-6832	Bit Screwdriver	6	EA	$ 0.73	$ 4.38
5120-00-640-6729	Bit Screwdriver	6	EA	$ 0.35	$ 2.10
5120-00-204-0985	Bit Screwdriver	6	EA	$ 1.41	$ 8.46
5120-00-528-2891	Holder Screwdriver Bit	2	EA	$ 1.33	$ 2.66
5120-00-528-2892	Holder Screwdriver Bit	2	EA	$ 1.88	$ 3.76
3460-00-540-1291	Arbor Hole Saw	1	EA	$ 4.87	$ 4.87
3460-00-293-1737	Arbor Hole Saw	1	EA	$ 4.51	$ 4.51
5140-00-329-4306	Pouch Mechanic's Tools	4	EA	$ 16.13	$ 64.52
5120-00-240-0155	Bender, Tube Hand	1	EA	$ 82.47	$ 82.47
5120-00-240-0152	Bender, Tube Hand	1	EA	$ 37.65	$ 37.65
5120-00-240-0154	Bender, Tube Hand	1	EA	$ 46.67	$ 46.67
5120-00-240-0153	Bender, Tube Hand	1	EA	$ 54.78	$ 54.78
5110-00-277-4587	Blade Hacksaw	3	BD	$ 6.16	$ 18.48
5110-00-277-4592	Blade Hacksaw	3	BD	$ 6.07	$ 18.21
3455-00-335-3039	Blade Hole Saw	1	EA	$ 4.00	$ 4.00
3455-00-335-3044	Blade Hole Saw	1	EA	$ 4.95	$ 4.95
3455-00-335-3042	Blade Hole Saw	1	EA	$ 3.65	$ 3.65
3455-00-335-3046	Blade Hole Saw	1	EA	$ 5.13	$ 5.13
3455-00-187-2628	Blade Hole Saw	1	EA	$ 5.07	$ 5.07
3455-00-187-2634	Blade Hole Saw	1	EA	$ 6.70	$ 6.70
3455-00-335-3037	Blade Hole Saw	1	EA	$ 3.07	$ 3.07
5130-00-275-1204	Blade Recip Saw	3	PG	$ 12.68	$ 38.04
5130-00-450-1501	Blade Recip Saw	3	PG	$ 16.95	$ 50.85
5120-00-180-0909	C-clamp	2	EA	$ 20.75	$ 41.50
5120-00-180-0908	C-clamp	2	EA	$ 16.46	$ 32.92
5110-00-186-7107	Chisel Cold	1	EA	$ 3.25	$ 3.25
5120-00-197-5344	Holder Sheet Metal Edge Grip	10	EA	$ 1.43	$ 14.30
5340-00-171-2754	Bolt Assembly, Clamp	25	EA	$ 3.36	$ 84.00
5325-01-037-1137	Fastener	25	EA	$ 2.86	$ 71.50

NSN	NOUN	REQ	UOI	COST	TOTAL
5325-01-037-5224	Fastener	25	EA	$ 4.40	$ 110.00
5325-00-171-2771	Insert Panel Fastener	25	EA	$ 2.86	$ 71.50
5120-00-541-1808	Holder Sheetmetal Hole	20	EA	$ 0.38	$ 7.60
5120-00-242-3791	Holder Sheetmetal Hole	20	EA	$ 0.38	$ 7.60
5120-00-222-3336	Holder Sheetmetal Hole	20	EA	$ 0.38	$ 7.60
5133-00-293-1902	Countersink Universal	6	EA	$ 6.15	$ 36.90
5120-00-469-7607	Crimping Tool Terminal Hand	1	EA	$ 197.00	$ 197.00
5120-00-595-8213	Crowsfoot Attachment Socket Wrench	1	EA	$ 10.50	$ 10.50
5120-00-184-8384	Crowsfoot Attachment Socket Wrench	1	EA	$ 8.34	$ 8.34
5120-00-236-2261	Crowsfoot Attachment Socket Wrench	1	EA	$ 7.51	$ 7.51
5120-00-184-8412	Crowsfoot Attachment Socket Wrench	1	EA	$ 11.98	$ 11.98
5120-00-293-2567	Crowsfoot Attachment Socket Wrench	1	EA	$ 14.33	$ 14.33
5120-00-184-8401	Crowsfoot Attachment Socket Wrench	1	EA	$ 6.97	$ 6.97
5120-00-184-8410	Crowsfoot Attachment Socket Wrench	1	EA	$ 10.82	$ 10.82
5120-00-184-8403	Crowsfoot Attachment Socket Wrench	1	EA	$ 14.43	$ 14.43
5120-00-184-8400	Crowsfoot Attachment Socket Wrench	1	EA	$ 6.62	$ 6.62
5120-00-184-8398	Crowsfoot Attachment Socket Wrench	1	EA	$ 7.97	$ 7.97
5120-00-184-8383	Crowsfoot Attachment Socket Wrench	1	EA	$ 7.30	$ 7.30
5120-00-541-4071	Crowsfoot Attachment Socket Wrench	1	EA	$ 5.81	$ 5.81
5120-00-184-8397	Crowsfoot Attachment Socket Wrench	1	EA	$ 8.32	$ 8.32
5110-00-293-3402	Cutter Tube Hand	2	EA	$ 20.73	$ 41.46
5110-00-443-4195	Cutting Wheel	10	EA	$ 7.87	$ 78.70
3460-00-234-3792	Disc Abor Wheel Abrasive	200	EA	$ 0.46	$ 92.00
5210-00-263-0376	Dividers Mechanic's	1	EA	$ 6.06	$ 6.06
5133-00-595-8855	Drill Twist	1	DZ	$ 68.72	$ 68.72
5133-00-449-6775	Drill Set Twist (60 pcs)	1	SE	$ 32.82	$ 32.82
5133-00-189-9264	Drill Twist	2	DZ	$ 8.95	$ 17.90
5133-00-189-9272	Drill Twist	2	DZ	$ 5.90	$ 11.80
5133-00-262-2192	Drill Twist	1	DZ	$ 16.05	$ 16.05
5133-00-262-2193	Drill Twist	1	DZ	$ 16.85	$ 16.85
5133-00-435-3276	Drill Twist	2	DZ	$ 15.26	$ 30.52
5133-00-435-3277	Drill Twist	2	DZ	$ 18.10	$ 36.20
5133-00-435-3246	Drill Twist	2	DZ	$ 12.28	$ 24.56
5133-00-435-3267	Drill Twist	2	DZ	$ 19.47	$ 38.94
Local Purchase	Drill Twist	12	EA		$ -
Local Purchase	Drill Twist	12	EA		$ -
Local Purchase	Drill Twist	12	EA		$ -
Local Purchase	Drill Twist	12	EA		$ -
5133-00-595-8861	Drill Twist	1	DZ	$ 56.70	$ 56.70
5133-00-595-8850	Drill Twist	1	DZ	$ 62.40	$ 62.40
5133-00-595-8849	Drill Twist	1	DZ	$ 61.71	$ 61.71
5133-00-988-5684	Drill Twist	4	DZ	$ 16.41	$ 65.64
5133-00-988-5678	Drill Twist	5	PK	$ 15.80	$ 79.00
5133-00-988-5673	Drill Twist	4	DZ	$ 12.88	$ 51.52
5133-00-988-5664	Drill Twist	4	DZ	$ 12.65	$ 50.60
5133-00-988-5655	Drill Twist	4	DZ	$ 12.39	$ 49.56
5133-00-988-5689	Drill Twist	4	DZ	$ 1.00	$ 4.00
5133-00-412-1748	Drill Twist	2	DZ	$ 23.75	$ 47.50

NSN	NOUN	REQ	UOI	COST	TOTAL
5133-00-988-5703	Drill Twist	2	DZ	$ 24.18	$ 48.36
5133-00-988-5711	Drill Twist	2	DZ	$ 48.84	$ 97.68
5133-00-988-5707	Drill Twist	2	DZ	$ 38.47	$ 76.94
5133-01-051-8701	Drill Twist	24	EA	$ 21.90	$ 525.60
5110-00-596-9323	Drill Breast	1	EA	$ 108.86	$ 108.86
5130-00-288-7750	Drill Pneumatic	2	EA	$ 173.28	$ 346.56
5130-00-957-2844	Drill Pneumatic	1	EA	$ 471.26	$ 471.26
5130-00-293-1978	Drill Pneumatic	1	EA	$ 405.58	$ 405.58
5130-00-540-4434	Drill Pneumatic	1	EA	$ 310.26	$ 310.26
5130-01-045-4866	Drill Pneumatic	1	EA	$ 410.08	$ 410.08
4240-00-022-2946	Protectors Hearing	6	EA	$ 4.88	$ 29.28
5120-00-018-0575	Inserter and remover Elect	10	EA	$ 0.63	$ 6.30
5120-00-915-4588	Inserter and remover Elect	10	EA	$ 0.85	$ 8.50
5120-00-915-4587	Inserter and remover Elect	10	EA	$ 0.62	$ 6.20
5120-00-157-3138	Inserter and remover Elect	10	EA	$ 1.16	$ 11.60
5120-00-243-7325	Extension Socket Wrench	1	EA	$ 1.69	$ 1.69
5120-00-243-1689	Extension Socket Wrench	2	EA	$ 6.59	$ 13.18
5120-00-222-4284	Remover, Pin	2	EA	$ 4.08	$ 8.16
5120-00-240-5223	Extractor	6	EA	$ 0.59	$ 3.54
5120-00-580-2359	Extractor	6	EA	$ 0.63	$ 3.78
5120-00-240-5221	Extractor	6	EA	$ 0.71	$ 4.26
5120-00-240-5222	Extractor	6	EA	$ 0.83	$ 4.98
4240-00-542-2048	Faceshield, industrial	2	EA	$ 10.11	$ 20.22
7920-00-224-7987	File Brush Cleaner	1	EA	$ 4.77	$ 4.77
5110-00-263-0349	File Handle	2	EA	$ 0.66	$ 1.32
5110-00-249-2858	File Hand	1	EA	$ 4.90	$ 4.90
5110-00-241-9153	File Hand	1	EA	$ 4.75	$ 4.75
5110-00-241-9148	File Hand	1	EA	$ 4.67	$ 4.67
5110-00-233-7683	File Hand	1	EA	$ 4.61	$ 4.61
3455-00-023-4277	File Rotary	6	EA	$ 3.94	$ 23.64
3455-00-023-4276	File Rotary	6	EA	$ 5.41	$ 32.46
3455-00-222-4063	File Rotary	6	EA	$ 7.61	$ 45.66
3455-00-023-4280	File Rotary	6	EA	$ 5.52	$ 33.12
3455-00-023-4281	File Rotary	6	EA	$ 4.47	$ 26.82
3455-00-023-4278	File Rotary	6	EA	$ 6.31	$ 37.86
3455-00-023-4279	File Rotary	6	EA	$ 3.02	$ 18.12
5110-00-234-6556	File Hand	1	EA	$ 2.07	$ 2.07
5110-00-234-6554	File Hand	1	EA	$ 3.38	$ 3.38
5110-00-373-1691	File Thread Restorer	1	EA	$ 5.81	$ 5.81
5110-00-516-3812	File Thread Restorer	1	EA	$ 6.54	$ 6.54
5110-00-156-0215	File Hand	1	EA	$ 7.52	$ 7.52
5110-00-204-2685	File Set Hand	1	SE	$ 44.65	$ 44.65
5120-01-144-7462	Flaring Tool Tube Hand	1	EA	$ 49.29	$ 49.29
6230-00-269-3034	Flashlight	2	EA	$ 6.97	$ 13.94
4240-00-516-4531	Glasses	4	EA	$ 5.98	$ 23.92
8415-00-268-7868	Gloves	6	PR	$ 16.25	$ 97.50
4240-00-052-3776	Goggles	4	EA	$ 1.75	$ 7.00
5130-01-079-1876	Grinder Pneumatic Horizontal	2	EA	$ 326.37	$ 652.74

NSN	NOUN	REQ	UOI	COST	TOTAL
5130-00-900-9514	Grinder Pneumatic Horizontal	1	EA	$ 128.55	$ 128.55
5210-00-221-1999	Gauge Thickness	1	EA	$ 4.01	$ 4.01
5110-00-289-9657	Hacksaw Frame	1	EA	$ 7.20	$ 7.20
5120-00-061-8543	Hammer Hand	2	EA	$ 9.75	$ 19.50
5120-00-596-1075	Hammer Face Insert	2	EA	$ 1.14	$ 2.28
5120-00-596-1071	Hammer Face Insert	2	EA	$ 6.25	$ 12.50
3465-00-517-1044	Drilling and Locating Fixture	1	EA	$ 17.75	$ 17.75
3465-00-250-8065	Drilling and Locating Fixture	1	EA	$ 9.30	$ 9.30
3465-00-517-1043	Drilling and Locating Fixture	1	EA	$ 17.24	$ 17.24
5120-00-233-6829	Jack Hydraulic Hand	1	EA	$ 91.45	$ 91.45
5120-00-568-0401	Driver Jo-Bolt	2	EA	$ 80.49	$ 160.98
5130-00-964-9444	Driver Jo-Bolt	2	EA	$ 702.79	$ 1,405.58
5210-01-140-4496	Jo-Bolt Grip Gauge	2	EA		$ -
5120-00-696-3343	Jo-Bolt Hex Nose	2	EA	$ 59.09	$ 118.18
5120-00-696-3341	Jo-Bolt Hex Nose	2	EA	$ 57.33	$ 114.66
5120-00-613-7430	Jo-Bolt Hex Nose	2	EA	$ 64.35	$ 128.70
5130-00-696-3348	Jo-Bolt Hex Nose	2	EA	$ 64.77	$ 129.54
5130-00-696-3346	Jo-Bolt Hex Nose	2	EA	$ 68.37	$ 136.74
5130-00-974-4815	Jo-Bolt Hex Nose	2	EA	$ 49.56	$ 99.12
3455-01-050-9863	Blade Circular Saw Cutting Metal	50	EA	$ 3.69	$ 184.50
5130-00-343-8945	Saw Circular Portable Pneumatic	1	EA	$ 303.02	$ 303.02
5110-00-240-5943	Knife Pocket	2	EA	$ 9.86	$ 19.72
5120-00-294-4605	Knife Putty	2	EA	$ 1.36	$ 2.72
6230-01-217-6350	Light Extension	1	EA	$ 200.00	$ 200.00
5120-00-545-4268	Retrieving Tool Magnetic	1	EA	$ 3.12	$ 3.12
5120-00-850-6313	Retrieving Tool Magnetic	1	EA	$ 7.23	$ 7.23
5120-00-903-8555	Holder Inserted Hammer Face	1	EA	$ 1.87	$ 1.87
3460-01-005-4810	Mandrel Machine Solid	2	EA	$ 3.39	$ 6.78
5120-00-629-6258	Fingers Mechanical	1	EA	$ 4.55	$ 4.55
5120-00-892-5709	Mirror Inspection	1	EA	$ 1.70	$ 1.70
6625-01-213-9354	Multimeter	1	EA	$ 65.00	$ 65.00
5120-00-624-8065	Pliers Slip Joint	1	EA	$ 15.38	$ 15.38
5120-00-278-0352	Pliers Slip Joint	1	EA	$ 10.30	$ 10.30
5120-00-221-1597	Forceps Sheet Holder	2	EA	$ 7.36	$ 14.72
5110-00-222-2708	Pliers	2	EA	$ 8.81	$ 17.62
5120-00-595-9519	Pliers	2	EA	$ 8.23	$ 16.46
5120-00-247-5177	Pliers	2	EA	$ 8.28	$ 16.56
5120-00-239-8250	Pliers	1	EA	$ 9.27	$ 9.27
5120-00-542-4171	Pliers Wire Twister	1	EA	$ 29.26	$ 29.26
5120-00-223-7396	Pliers Slip Joint	1	EA	$ 4.99	$ 4.99
5120-00-965-0604	Wrench Plier	2	EA	$ 5.46	$ 10.92
5120-00-494-1910	Wrench Plier	2	EA	$ 6.23	$ 12.46
5120-01-336-7975	Clamp Plier	2	EA	$ 13.21	$ 26.42
5120-01-108-9649	Wrench Plier	2	EA	$ 10.53	$ 21.06
6150-01-251-7411	Power Strip Electric Outlet	2	EA	$ 35.04	$ 70.08
5120-00-293-3512	Punch center Solid	2	EA	$ 2.27	$ 4.54
5120-00-240-6083	Punch Drive Pin	2	EA	$ 0.93	$ 1.86
5120-00-242-5966	Punch Drive Pin	6	EA	$ 0.82	$ 4.92

NSN	NOUN	REQ	UOI	COST	TOTAL
5120-00-293-0791	Punch Drive Pin	2	EA	$ 0.90	$ 1.80
5120-00-242-3435	Punch Drive Pin	6	EA	$ 0.77	$ 4.62
5120-00-240-6104	Punch Drive Pin	2	EA	$ 0.82	$ 1.64
5130-00-541-0501	Saw Reciprocating Portable Pneumatic	1	EA	$ 181.05	$ 181.05
5130-01-145-0206	Extension Riveter Blind	1	EA	$ 112.91	$ 112.91
5130-01-145-0207	Extension Riveter Blind	1	EA	$ 119.34	$ 119.34
5130-01-145-0208	Extension Riveter Blind	1	EA	$ 180.65	$ 180.65
5210-00-255-7544	Gauge Rivet selector	3	EA	$ 9.69	$ 29.07
5130-01-397-6805	Riveter Blind Pneumatic	3	EA	$ 283.95	$ 851.85
5120-01-430-5346	Pulling Head Riveter	2	EA	$ 377.91	$ 755.82
5120-01-430-5328	Pulling Head Riveter	2	EA	$ 284.43	$ 568.86
5120-01-397-6806	Riveter Blind Fastener	2	EA	$ 462.27	$ 924.54
5210-00-234-5224	Rule Steel Machinist	1	EA	$ 6.60	$ 6.60
5210-00-234-5223	Rule Steel Machinist	2	EA	$ 2.94	$ 5.88
5110-00-255-0420	Scissors, Electrician	1	EA	$ 6.88	$ 6.88
5120-00-222-8852	Screwdriver, Flat Tip	2	EA	$ 0.97	$ 1.94
5120-00-293-3311	Screwdriver, Flat Tip	1	EA	$ 1.50	$ 1.50
5120-00-293-0315	Screwdriver, Flat Tip	2	EA	$ 1.96	$ 3.92
5120-00-293-3159	Screwdriver, Flat Tip	1	EA	$ 3.05	$ 3.05
5120-00-260-4837	Screwdriver, Flat Tip	1	EA	$ 1.31	$ 1.31
5120-00-596-9364	Screwdriver, Flat Tip	1	EA	$ 1.49	$ 1.49
5120-00-240-8716	Screwdriver, Cross Tip	1	EA	$ 0.83	$ 0.83
5120-00-224-7375	Screwdriver, Cross Tip	1	EA	$ 2.87	$ 2.87
5120-00-287-2130	Screwdriver, Offset	1	EA	$ 6.98	$ 6.98
5120-00-227-7293	Screwdriver, Cross Tip	2	EA	$ 1.20	$ 2.40
5120-00-234-8913	Screwdriver, Cross Tip	2	EA	$ 2.07	$ 4.14
5120-00-234-8912	Screwdriver, Cross Tip	1	EA	$ 3.34	$ 3.34
5120-00-542-3438	Screwdriver, Cross Tip	2	EA	$ 1.91	$ 3.82
5120-00-227-7377	Screwdriver, Flat Tip	1	EA	$ 0.89	$ 0.89
5120-00-293-3309	Screwdriver, Flat Tip	2	EA	$ 2.02	$ 4.04
5120-00-596-8502	Screwdriver, Flat Tip	1	EA	$ 1.34	$ 1.34
5120-00-256-9014	Screwdriver, Offset	1	EA	$ 2.99	$ 2.99
5120-00-596-1543	Scribe, Machine's	2	EA	$ 0.90	$ 1.80
5120-00-595-9573	Screwdriver, Ratchet	1	EA	$ 6.41	$ 6.41
3445-00-244-4527	Shear Machine Head Throatles	1	EA	$ 10.00	$ 10.00
5110-00-273-0126	Shears Metal Cutting Head	1	EA	$ 21.52	$ 21.52
5110-00-273-0127	Shears Metal Cutting Head	1	EA	$ 10.00	$ 10.00
5110-00-273-0128	Shears Metal Cutting Head	1	EA	$ 10.00	$ 10.00
5130-00-221-1083	Shears Metal Cutting Head	1	EA	$ 21.52	$ 21.52
5120-00-081-2305	Socket Wrench Set 1/4 14 PC	1	SE	$ 26.78	$ 26.78
5120-00-189-8610	Socket, Socket Wrench	1	EA		$ -
5120-00-242-3351	Socket, Socket Wrench	1	EA		$ -
5120-00-242-3352	Socket, Socket Wrench	1	EA		$ -
5120-00-235-5878	Socket, Socket Wrench	1	EA		$ -
5120-00-235-5869	Socket, Socket Wrench	1	EA		$ -
5120-00-236-2264	Socket, Socket Wrench	1	EA		$ -
5120-00-236-2263	Socket, Socket Wrench	1	EA		$ -
5120-00-242-3345	Socket, Socket Wrench	1	EA		$ -

NSN	NOUN	REQ	UOI	COST	TOTAL
5120-00-243-1686	Universal Joint, Socket Wrench	1	EA		$ -
5120-00-322-6231	Socket Wrench Set 3/8 23 PC	1	SE	$ 75.53	$ 75.53
5120-00-237-0977	Socket, Socket Wrench	1	EA		$ -
5120-00-243-1691	Extension, Socket Wrench	1	EA		$ -
5120-00-227-8107	Extension, Socket Wrench	1	EA		$ -
5120-00-240-5396	Handle, Socket Wrench	1	EA		$ -
5120-00-240-5364	Handle, Socket Wrench	1	EA		$ -
5120-00-232-5706	Socket, Socket Wrench	1	EA		$ -
5120-00-235-5807	Socket, Socket Wrench	1	EA		$ -
5120-00-227-6705	Socket, Socket Wrench	1	EA		$ -
5120-00-227-6702	Socket, Socket Wrench	1	EA		$ -
5120-00-237-4973	Socket, Socket Wrench	1	EA		$ -
5120-00-227-6703	Socket, Socket Wrench	1	EA		$ -
5120-00-242-3330	Socket, Socket Wrench	1	EA		$ -
5120-00-277-4252	Socket, Socket Wrench	1	EA		$ -
5120-00-239-0018	Socket, Socket Wrench	1	EA		$ -
5120-00-239-0017	Socket, Socket Wrench	1	EA		$ -
5120-00-596-0836	Socket, Socket Wrench	1	EA		$ -
5120-00-227-6704	Socket, Socket Wrench	1	EA		$ -
5120-00-241-3185	Socket, Socket Wrench	1	EA		$ -
5120-00-235-5879	Socket, Socket Wrench	1	EA		$ -
5120-00-224-9215	Universal Joint, Socket Wrench	1	EA		$ -
5120-00-242-3355	Socket, Socket Wrench	1	EA		$ -
5120-00-237-0978	Socket, Socket Wrench	1	EA		$ -
5120-00-081-2307	Socket Wrench Set 1/2 20 Pc.	1	SE	$ 88.17	$ 88.17
5120-00-227-8074	Extension, Socket Wrench	1	EA		$ -
5120-00-243-1697	Extension, Socket Wrench	1	EA		$ -
5120-00-243-7326	Extension, Socket Wrench	1	EA		$ -
5120-00-236-7590	Handle, Socket Wrench	1	EA		$ -
5120-00-221-7958	Handle, Socket Wrench	1	EA		$ -
5120-00-230-6385	Handle, Socket Wrench	1	EA		$ -
5120-00-189-7927	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7913	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7917	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7914	Socket, Socket Wrench	1	EA		$ -
5120-00-237-0984	Socket, Socket Wrench	1	EA		$ -
5120-00-235-5870	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7933	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7935	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7985	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7946	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7924	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7934	Socket, Socket Wrench	1	EA		$ -
5120-00-189-7932	Socket, Socket Wrench	1	EA		$ -
5120-00-269-7971	Universal Joint, Socket Wrench	1	EA		$ -
5120-00-221-7957	Handle Socket Wrench	1	EA	$ 6.39	$ 6.39
5120-00-962-8343	Socket	1	EA	$ 4.30	$ 4.30
5120-00-288-8155	Socket	1	EA	$ 2.85	$ 2.85

NSN	NOUN	REQ	UOI	COST	TOTAL
5120-00-232-5711	Socket	1	EA	$ 0.89	$ 0.89
5120-00-243-7340	Socket deep well	1	EA	$ 5.63	$ 5.63
5120-00-243-7346	Socket deep well	1	EA	$ 4.00	$ 4.00
5120-00-243-7341	Socket deep well	1	EA	$ 5.25	$ 5.25
5120-00-243-7345	Socket deep well	1	EA	$ 4.38	$ 4.38
5120-00-243-7343	Socket deep well	1	EA	$ 5.80	$ 5.80
5120-00-243-7348	Socket deep well	1	EA	$ 4.63	$ 4.63
5120-00-775-6983	Socket deep well	1	EA	$ 2.90	$ 2.90
5120-00-596-1163	Socket deep well	1	EA	$ 0.91	$ 0.91
5120-00-235-5822	Socket deep well	1	EA	$ 3.60	$ 3.60
5120-00-775-6980	Socket deep well	1	EA	$ 4.65	$ 4.65
5120-00-948-3214	Socket deep well	1	EA	$ 4.47	$ 4.47
5120-00-235-5821	Socket deep well	1	EA	$ 7.12	$ 7.12
5120-00-277-1463	Socket deep well	1	EA	$ 0.63	$ 0.63
5120-00-277-1464	Socket deep well	1	EA	$ 2.66	$ 2.66
3439-00-542-0454	Soldering Iron Elect.	1	EA	$ 24.41	$ 24.41
5120-00-249-1071	Speed Handle	1	EA	$ 12.63	$ 12.63
5120-00-237-4969	Speed Handle	3	EA	$ 7.79	$ 23.37
5120-00-227-8129	Speed Handle	1	EA	$ 26.08	$ 26.08
5120-01-367-3188	Spline Socket	1	EA	$ 14.49	$ 14.49
5120-01-367-3191	Spline Socket	1	EA	$ 14.64	$ 14.64
5120-01-367-3193	Spline Socket	1	EA	$ 14.64	$ 14.64
5120-01-367-3195	Spline Socket	1	EA	$ 14.64	$ 14.64
5120-01-367-3192	Spline Socket	1	EA	$ 12.21	$ 12.21
5120-01-367-3194	Spline Socket	1	EA	$ 14.64	$ 14.64
5120-01-367-3189	Spline Socket	1	EA	$ 14.64	$ 14.64
5120-01-367-3167	Spline Socket	1	EA	$ 22.80	$ 22.80
5120-01-367-3165	Spline Socket	1	EA	$ 8.29	$ 8.29
5120-01-367-3164	Spline Socket	1	EA	$ 6.92	$ 6.92
5120-01-367-3184	Spline Socket	1	EA	$ 23.85	$ 23.85
5120-01-367-3161	Spline Socket	1	EA	$ 8.29	$ 8.29
5120-01-367-3163	Spline Socket	1	EA	$ 8.29	$ 8.29
5210-00-241-3599	Square Combination	1	EA	$ 25.76	$ 25.76
Local Manufacture	T' Air Fitting Assembly	4	EA	$ 6.95	$ 27.80
5120-00-277-4063	Tap Thread Cutting	1	EA	$ 23.96	$ 23.96
5136-00-227-8618	Tap Thread Cutting	2	EA	$ 2.06	$ 4.12
5136-00-729-5700	Tap Thread Cutting	2	EA	$ 1.66	$ 3.32
5136-00-203-6506	Tap Thread Cutting	2	EA	$ 1.83	$ 3.66
5210-00-150-2920	Tape Measuring	2	EA	$ 6.90	$ 13.80
7910-00-807-3704	Cleaner Vacuum Pneumatic	2	EA	$ 48.12	$ 96.24
5120-00-180-0681	Vise Machinist's	1	EA	$ 70.61	$ 70.61
5120-00-554-7406	Crimp Tool Terminal Head	1	EA	$ 208.35	$ 208.35
5110-00-268-4220	Stripper Wire Head	1	EA	$ 27.89	$ 27.89
5110-00-177-7286	Stripper Wire Head	1	EA	$ 125.99	$ 125.99
5120-00-240-5336	Wrench Adjustable	2	EA	$ 31.52	$ 63.04
5120-00-449-8083	Wrench Adjustable	1	EA	$ 10.43	$ 10.43
5120-00-264-3796	Wrench Adjustable	1	EA	$ 14.28	$ 14.28
5120-00-264-3795	Wrench Adjustable	1	EA	$ 8.64	$ 8.64

NSN	NOUN	REQ	UOI	COST	TOTAL
5120-00-240-5328	Wrench Adjustable	1	EA	$ 9.50	$ 9.50
5120-00-204-2670	Wrench Box	1	EA	$ 13.19	$ 13.19
5120-00-596-8556	Wrench Box	1	EA	$ 6.42	$ 6.42
5120-00-935-7358	Wrench Box	1	EA	$ 19.08	$ 19.08
5120-00-293-0081	Wrench Box	1	EA	$ 12.07	$ 12.07
5120-00-264-5216	Wrench Box	1	EA	$ 9.71	$ 9.71
5120-00-277-1438	Wrench Box	1	EA	$ 17.30	$ 17.30
5120-00-184-8602	Wrench Box	1	EA	$ 18.58	$ 18.58
5120-01-379-5440	Wrench Box	1	EA	$ 15.64	$ 15.64
5120-01-378-4874	Wrench Box	1	EA	$ 19.43	$ 19.43
5120-00-224-3146	Wrench Box	1	EA	$ 5.66	$ 5.66
5120-00-891-6679	Wrench Box	1	EA	$ 17.63	$ 17.63
5120-00-222-1593	Wrench Box	1	EA	$ 11.26	$ 11.26
5120-00-222-1592	Wrench Box	1	EA	$ 10.11	$ 10.11
5120-00-277-3364	Wrench Box	1	EA	$ 6.15	$ 6.15
5120-00-288-7684	Wrench Box	1	EA	$ 12.75	$ 12.75
5120-00-228-9506	Wrench Box and Open End Combination	1	EA	$ 2.81	$ 2.81
5120-00-288-9997	Wrench Box and Open End Combination	1	EA	$ 2.65	$ 2.65
5120-00-228-9509	Wrench Box and Open End Combination	1	EA	$ 3.58	$ 3.58
5120-00-278-0342	Wrench Box and Open End Combination	1	EA	$ 4.63	$ 4.63
5120-00-228-9511	Wrench Box and Open End Combination	1	EA	$ 6.38	$ 6.38
5120-00-228-9513	Wrench Box and Open End Combination	1	EA	$ 8.93	$ 8.93
5120-00-228-9510	Wrench Box and Open End Combination	1	EA	$ 4.33	$ 4.33
5120-00-228-9504	Wrench Box and Open End Combination	1	EA	$ 2.70	$ 2.70
5120-00-228-9503	Wrench Box and Open End Combination	1	EA	$ 2.72	$ 2.72
5120-00-228-9508	Wrench Box and Open End Combination	1	EA	$ 3.14	$ 3.14
5120-00-228-9505	Wrench Box and Open End Combination	1	EA	$ 2.65	$ 2.65
5120-00-228-9512	Wrench Box and Open End Combination	1	EA	$ 7.99	$ 7.99
5120-00-228-9507	Wrench Box and Open End Combination	1	EA	$ 2.97	$ 2.97
5120-00-288-9671	Wrench Box and Open End Combination	1	EA	$ 6.98	$ 6.98
5120-00-228-9514	Wrench Box and Open End Combination	1	EA	$ 10.47	$ 10.47
5120-01-072-2956	Wrench Impact Manual	1	EA	$ 21.14	$ 21.14
5120-00-228-9527	Wrench Open End	1	EA	$ 5.34	$ 5.34
5120-00-277-2308	Wrench Open End	1	EA	$ 2.60	$ 2.60
5120-00-277-2311	Wrench Open End	1	EA	$ 5.06	$ 5.06
5120-00-277-1324	Wrench Open End	1	EA	$ 11.75	$ 11.75
5120-00-293-1794	Wrench Open End	1	EA	$ 16.51	$ 16.51
5120-00-288-8216	Wrench Open End	1	EA	$ 6.57	$ 6.57
5120-00-293-1796	Wrench Open End	1	EA	$ 11.65	$ 11.65
5120-00-293-2136	Wrench Open End	1	EA	$ 17.67	$ 17.67
5120-00-293-1795	Wrench Open End	1	EA	$ 19.47	$ 19.47

NSN	NOUN	REQ	UOI	COST	TOTAL
5120-00-595-9017	Wrench Open End	1	EA	$ 20.66	$ 20.66
5120-00-184-8652	Wrench Open End	1	EA	$ 12.89	$ 12.89
5120-00-184-8654	Wrench Open End	1	EA	$ 19.05	$ 19.05
5120-00-293-0053	Wrench Open End	1	EA	$ 12.55	$ 12.55
5120-01-335-1227	Wrench Open End	1	EA	$ 12.38	$ 12.38
5120-01-335-1225	Wrench Open End	1	EA	$ 7.88	$ 7.88
5120-00-288-8215	Wrench Open End	1	EA	$ 7.80	$ 7.80
5120-01-335-1228	Wrench Open End	1	EA	$ 10.48	$ 10.48
5120-00-184-8559	Wrench Open End	1	EA	$ 12.97	$ 12.97
5120-01-335-1194	Wrench Open End	1	EA	$ 14.73	$ 14.73
5120-00-234-4879	Wrench Impact Pneumatic	2	EA	$ 148.86	$ 297.72
5120-01-367-3305	Wrench Box End	1	EA	$ 14.57	$ 14.57
5120-01-367-3310	Wrench Box End	1	EA	$ 39.86	$ 39.86
5120-01-367-3304	Wrench Box End	1	EA	$ 16.28	$ 16.28
5120-01-367-3352	Wrench Box and Open End Combination	1	EA	$ 13.03	$ 13.03
5120-01-367-3348	Wrench Box and Open End Combination	1	EA	$ 12.20	$ 12.20
5120-01-367-3355	Wrench Box and Open End Combination	1	EA	$ 12.85	$ 12.85
5120-01-367-3356	Wrench Box and Open End Combination	1	EA	$ 19.44	$ 19.44
5120-01-367-3350	Wrench Box and Open End Combination	1	EA	$ 12.20	$ 12.20
5120-01-367-3349	Wrench Box and Open End Combination	1	EA	$ 8.55	$ 8.55
5120-01-367-3354	Wrench Box and Open End Combination	1	EA	$ 13.11	$ 13.11
5120-01-367-3351	Wrench Box and Open End Combination	1	EA	$ 11.95	$ 11.95
5120-01-367-3353	Wrench Box and Open End Combination	1	EA	$ 15.37	$ 15.37
					$ 16,492.01

Shelf Life

NSN	NOUN	REQ	UOI	COST	Total Cost
8030-01-290-5139	Sealing Comp.	6	EA	$37.70	$ 226.20
8030-01-290-5135	Sealing Comp.	6	EA	$44.34	$ 266.04
6545-00-922-1200	First Aid Kit	1	KT	$49.16	$ 49.16
5970-00-019-5620	Tape , teflon	4	RO	$40.38	$ 161.52
6135-00-835-7210	Battery	4	PG	$ 9.31	$ 37.24
5970-00-812-7387	Tape	4	RO	$ 7.23	$ 28.92
5970-00-955-9976	Tape, Insulation	4	RO	$ 7.52	$ 30.08
9320-00-291-8468	Rubber Sheet, 36" Square,	1	EA	$54.90	$ 54.90
6515-00-462-0832	Gloves, Surgical	1	BX	$ 6.72	$ 6.72
3439-00-555-4629	Solder, Tin Alloy,	1	SL	$ 4.73	$ 4.73
8040-00-941-9984	Adhesive	6	KT	$ 8.45	$ 50.70
8040-00-092-2816	Adhesive, Epoxy	1	BX	$19.60	$ 19.60
8030-01-265-2895	Epoxy Tabs,	1	BX	$88.41	$ 88.41
4720-00-683-8830	Hose, High Pressure	20	FT	$ 2.17	$ 43.40
4720-00-554-8084	Hose, High Pressure	10	FT	$ 2.29	$ 22.90
4720-00-554-8085	Hose, High Pressure	20	FT	$ 2.40	$ 48.00
4720-00-554-8086	Hose, High Pressure	20	FT	$ 3.59	$ 71.80
4720-00-554-8087	Hose, High Pressure	6	FT	$ 2.65	$ 15.90
4720-00-554-8088	Hose, High Pressure	6	FT	$ 3.90	$ 23.40
4720-00-554-8089	Hose, High Pressure	6	FT	$ 4.88	$ 29.28
					$1,278.90

Composite List

NSN	NOUN	REQ	UOI	COST	TOTAL
4330PF4KIT001	Hot Bonder HB-1	1	EA	$4,613.85	$4,613.85
6670-00-494-3604	Scale Weighing	1	EA	$105.57	$105.57
9535-00-825-4239	Strip Metal	1	SP	$9.70	$9.70
9330-01-225-9550	Film Nonporous Release	0.5	RO	$812.68	$406.34
9330-00-394-3554	Film, Polyvinyl Alcohol .002	0.3	RO	$575.10	$172.53
8135-00-050-7698	Film, Polyvinyl Alcohol .020	0.5	RO	$311.85	$155.93
8305-01-100-9061	Fabric Porous Release	10	YD	$4.12	$41.20
6640-00-855-8762	Bottle, Plastic	1	EA	$2.05	$2.05
5120-01-010-4522	Dial Calipers	2	EA	$150.76	$301.52
7520-00-240-2417	Dispenser, Tape 1"	1	EA	$5.25	$5.25
7520-00-624-6724	Dispenser, Tape 3"	1	EA	$16.23	$16.23
5130-00-540-4434	Drill w/key 3/8	1	EA	$255.79	$255.79
7910-01-135-7014	Hand Vacuum 90 PSI	2	EA	$74.66	$149.32
5130-00-618-4445	Router	1	EA	$236.47	$236.47
5130-00-900-9514	Sander	1	EA	$112.56	$112.56
5130-00-606-9694	Sander	2	EA	$118.56	$237.12
	Thermocouple, k type	4	EA	$11.52	$46.08
6685-01-292-7873	Thermometer, Digital (J/K)	1	EA	$172.64	$172.64
8305-00-262-3321	Cheese Cloth	1	BO	$31.12	$31.12
7920-01-004-7847	Cloth Cleaning	1	RO	$10.97	$10.97
6515-00-462-0832	Composite work gloves	3	PG	$5.94	$17.82
7350-00-641-4520	Paper cups	0.4	BX	$34.53	$13.81
8305-00-274-3976	Fiberglass Cloth 120	10	YD	$3.25	$32.50
8305-00-530-0111	Fiberglass Cloth 181	10	YD	$6.18	$61.80
4920P939744F	Diamond tip cutting kit	1	EA	$2,472.00	$2,472.00
	Diamond Tip Cutting Kit				$0.00
	Diamond Core Drill-2"	3	EA		$0.00
	Diamond Core Drill-1-1/2"	3	EA		$0.00
	Diamond Core Drill-1"	3	EA		$0.00
	Diamond Core Drill-3/4"	3	EA		$0.00
	Arbor	1	EA		$0.00
	Sharpener	1	EA		$0.00
	Template	1	EA		$0.00
	Template	1	EA		$0.00
	Template	1	EA		$0.00
	Template	1	EA		$0.00
	Sanding Discs 60grit-1"		EA		$0.00
	Sanding Discs 120grit-1"		EA		$0.00
	Sanding Discs 240grit-1"		EA		$0.00
	Sanding Discs 40grit-1"		EA		$0.00
	Sanding Discs 80grit-1"		EA		$0.00
	Sanding Discs 120grit-1"		EA		$0.00
	Sanding Discs 40grit-1"		EA		$0.00
	Sanding Discs 80grit-1"		EA		$0.00
	Sanding Discs 120grit-1"		EA		$0.00
	Sanding Discs 40grit-1"		EA		$0.00
	Sanding Discs 80grit-1"		EA		$0.00

NSN	NOUN	REQ	UOI	COST	TOTAL
	Sanding Discs 120grit-1"		EA		$0.00
	Diamond Router-1/4"	3	EA		$0.00
	Diamond Router-1/4"	3	EA		$0.00
	Carbide Router-1/4"	3	EA		$0.00
	Mounted Diamond Point-1/8"	10	EA		$0.00
	Carbide Twist Drill-1/8"	10	EA		$0.00
Local Purchase	Battery, 9-Volt	2	EA		$0.00
3455P939731F	Carbide Reamer #16 (.1770)	25	EA	$12.05	$301.25
3455P939732F	Carbide Reamer #8 (.2055)	25	EA	$13.74	$343.50
3455P939768F	Carbide Reamer 21/64 (.2188)	25	EA	$13.83	$345.75
3455P939733F	Carbide Reamer 7/32 (.2770)	25	EA	$16.27	$406.75
3455P939734F	Carbide Reamer J (.3281)	25	EA	$18.34	$458.50
5935-01-085-3999	Clamp Cable Part 2	6	EA	$3.36	$20.16
5935-01-107-6111	Connector Body Part 1	6	EA	$2.15	$12.90
3455-01-087-2242	Core Slicer Router Bit	5	EA	$50.43	$252.15
5133-01-335-3464	Counter Sink 3/16	2	EA	$24.14	$48.28
5133-01-335-3483	Counter Sink 5/32	2	EA	$24.14	$48.28
5110-00-268-3883	Craftsman Knife	2	EA	$3.65	$7.30
5110-00-359-6478	Exacto knife blades	10	PG	$0.42	$4.20
5110-00-595-8400	Knife, Craftsman	1	EA	$1.66	$1.66
5110-00-344-9900	Knife, Handcraft	1	EA	$3.79	$3.79
6650-00-252-6250	Magnifying Glass	2	EA	$6.48	$12.96
5120-00-247-0868	Medical, Tweezers	6	EA	$5.14	$30.84
5120-00-294-4605	Putty Knife 1/2"	2	EA	$1.20	$2.40
5110-00-255-0420	Scissors 6"	1	EA	$5.08	$5.08
5305-00-144-4024	Screws for thermocouples	1	HD	$0.17	$0.17
5120-00-056-3237	Spatula set	1	EA	$4.74	$4.74
3230PPAI-7300	Split Helix Router Bit	10	EA	$31.53	$315.30
5350-00-721-8115	Paper	2	PG	$9.23	$18.46
5350-00-721-8117	Paper	2	PG	$8.42	$16.84
5350-00-224-7207	Paper	2	PG	$7.42	$14.84
7920-00-045-2940	Scotch Brite Pad	1	BX	$12.28	$12.28
7510-00-537-6930	Aircraft Marking Pencil	1	DZ	$4.98	$4.98
7520-00-904-1265	Marker, Black	2	PG	$2.27	$4.54
7520-01-207-4159	Marker, White	1	DZ	$24.60	$24.60
5345-01-015-1419	Sanding disks kit	1	KT	$41.36	$41.36
5120-00-628-5569	Squeegee	1	BX	$17.39	$17.39
7510-00-584-2848	Tape	6	RO	$4.38	$26.28
7510-01-108-0174	Tape	1	RO	$23.78	$23.78
7510-00-266-5016	Tape	1	RO	$7.56	$7.56
7510-00-266-6710	Tape	6	RO	$1.24	$7.44
7920-00-514-2417	ACID BRUSHES	1	GR	$4.75	$4.75
4240-01-235-0823	FILTER RETAINERS	1	BX	$22.78	$22.78
4240-01-246-5407	FILTER, ORGANIC	1	BX	$30.73	$30.73
6515-00-324-5500	TONGUE DEPRESSOR	10	BX	$1.33	$13.30
With GM-811	Y Adapter - 3 x 1-1/2"	1	EA		$0.00
With GM-811	1.5" Sanding System Inlet Coupler	1	EA		$0.00

NSN	NOUN	REQ	UOI	COST	TOTAL
With GM-811	2" Fixed Head Dust Shroud	1	EA		$0.00
With GM-811	3" Fixed Head Dust Shroud	1	EA		$0.00
With GM-811	3" Round Dust Brush	1	EA		$0.00
With GM-811	Drill Shield Assembly-1/4" to 1/2"	1	EA		$0.00
With GM-811	Hose Fitting Connector-Sanding System	1	EA		$0.00
With GM-811	Sander Hose Connector	1	EA		$0.00
With GM-811	3/32 Allen Wrench	2	EA		$0.00
With GM-811	Clear Plastic Ring (for the dust shroud)	2	EA		$0.00
7910P9397352067	GM-811 Vacuum Kit	1	EA	$2,200.19	$2,200.19
With GM-811	15' Coaxial Hose	1	EA		$0.00
7910-01-124-2778	Disposable Paper Bags (PG=5)	1	PG		$0.00
	Stanley Vidmar Tool Box	2	EA		$0.00
					$16,331.69

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14. ABSTRACT
Air superiority is essential in today's wartime environment. Aircraft that are damaged and not returned to combat can have a considerable impact on the quest for dominance in the air. To maintain operational effectiveness, an organization must have the capability to quickly repair damaged aircraft. The purpose of an Aircraft Battle Damage Repair (ABDR) program is to rapidly and effectively repair damaged aircraft to fly additional operational sorties and further contribute to wartime objectives. This capability must consist of providing the necessary tools and equipment for the rapid repair of aircraft. When an ABDR team deploys in support of an organization in a wartime environment, it is expected that the team will be fully functional, autonomous, and have on hand the resources necessary to complete all tasks. From a logistics standpoint, this is a feasible objective using different methods, with the present method used being prepositioning. During combat operations, Air Mobility Command (AMC) is heavily tasked with movement of personnel and equipment. The prepositioning of ABDR trailers could provide relief on AMC resources already strained to their limits. This research seeks to determine if the AF should continue to preposition ABDR trailers to augment strategic airlift during combat operations by determining the best course of action for providing ABDR trailers to ABDR teams during combat operations. This research will evaluate the effectiveness of both prepositioning and airlifting ABDR trailers.

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